Sneezing, *captured on a special shadow photograph, sprays millions of bacteria that can pass on infection in the air.*

Malcolm Fielding, Johnson Matthey plc/SPL

GERM WARFARE

Dr Gary Settles/SPL

Protective clothing *and air-tight visors are worn to prevent researchers coming into contact with germs.*

GERMS POSE A CONSTANT threat that we must guard against. The body is equipped with a very powerful defence system – the immune system. It is a collection of cells – the white blood cells – programmed with the special tasks of seeking out and destroying germs.

Germs are a group of organisms that cause disease. This group is split into bacteria, viruses, fungi, protozoa and parasites.

There are thousands of different types of bacteria, but they all share one basic feature – they can only be seen under a microscope. Some need very high-power magnification to become visible.

Each bacterium (singular for bacteria) is made up of a single cell, less than 0.01 mm in diameter – about 16 times thinner than a human hair.

Fast breeders

Bacteria are of four basic shapes and they are named accordingly: they may be spherical (coccus), rod-shaped (bacillus), curved rod shape (vibro) or spiral (spirillum).

Bacteria have a remarkable rate of reproduction. In perfect conditions, one bacterium can produce 1,000,000 copies of itself in 7 hours. In practice this rarely happens because their food is insufficient.

The good, the bad . . .

Bacteria live all over our bodies and are very important to health (especially in the gut where they make vitamin K which is important in blood clotting). Not all bacteria are good for health, of course, but there is a balance in the number of both types. If this balance alters (for example, if you don't brush your teeth, and harmful bacteria are allowed to outnumber the good bacteria) then disease occurs – in

this case caries, or tooth decay.

Viruses can only be seen through an electron microscope. The smallest virus is 0.00001 mm long – about 16,000 times less than the diameter of a human hair.

Double lives

Viruses can exist in either a living or a non-living state. When outside their host (the organism they live in) they are crystals and can live for any length of time in this state – they can even survive in space. Once inside the host, however, they become active and start to invade the host's body cells. They take over the cell's life functions for their own use and reproduce until the cell dies. The new viruses are then released to infect other cells, and the cycle is repeated. This is the reason viral infections progress so quickly and that patients can fall ill so suddenly.

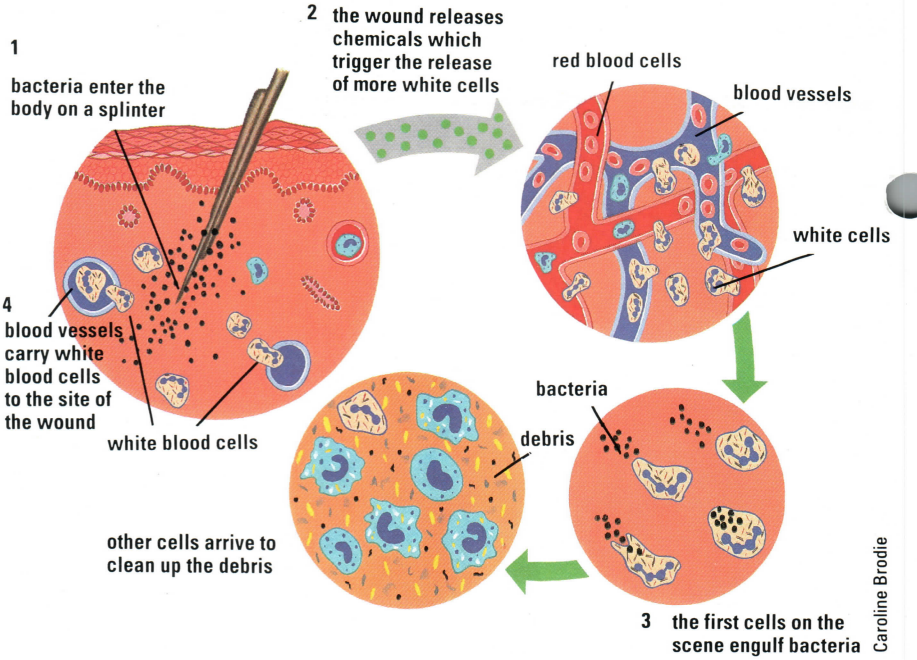
The common cold is a typical viral infection. It starts with sneezing, headaches and joint and muscle pains. Once the body starts producing mucus in the nose and throat, then other bacteria begin to thrive. The cold then starts to become runny and the mucus turns green due to the bacteria living in it – this is called a secondary bacterial infection, a common complication.

Other viral infections include polio, chickenpox and measles in humans; foot-and-mouth in cattle, distemper in dogs and myxomatosis in rabbits. Certain viruses are linked with the development of cancer.

The damp, moist conditions that favour bacterial growth also encourage the growth of fungi.

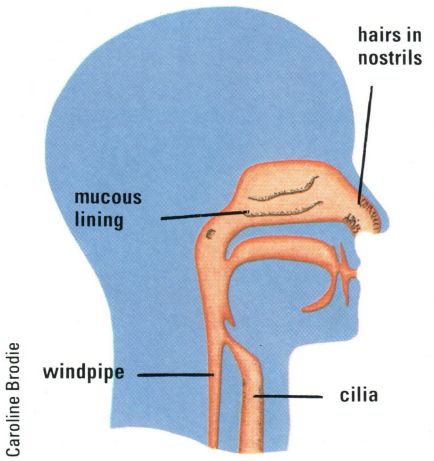
Itchy feet

A good example of fungal infection is athlete's foot – seen between the toes as a white, scaly rash which is very itchy. The same type of itchy rash can occur on the head and



Caroline Brodie

Bacteria *entering the skin on a splinter alert the body's defences (1). Chemical messages from the wound travel through the blood and cause white blood cells to rush to the site (2). The first white cells on the scene engulf the bacteria and are killed along with the bacteria they engulf (3). Other white cells arrive and clean up the debris (4).*



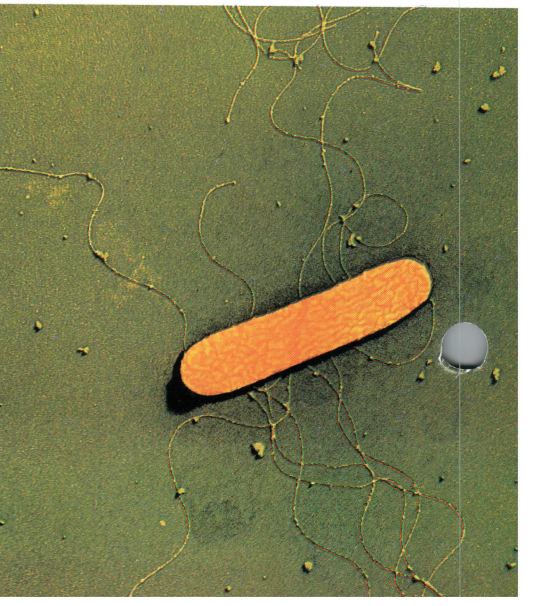
Caroline Brodie

The nose and mouth *are lined with mucus and cilia (hair-like tissue), both of which trap germs that are inhaled.*

CNRI/SPL

St Bartholomew's Hospital/SPL

Cold sores *are small blisters caused by the herpes virus (above). Virus particles (orange) move from the nucleus (green) to the surrounding fluid (blue) of a cell they have infected. The blisters are unsightly, but not life-threatening.*

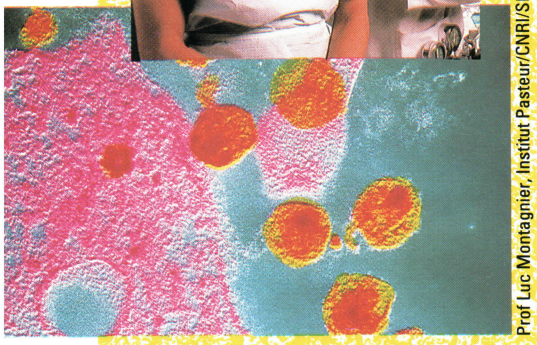


A B Dowsett/SPL

Listeria bacteria *cause food poisoning; the bacteria grow well in food that is not kept cold enough.*

AIDS – WHEN THE BODY LOSES ITS DEFENCES

Lawrence Migdale/SPL



Prof Luc Montagnier, Institut Pasteur/CNRI/SPL

Our immune system is very effective in its action, but it can break down. The best known example of a break down in the immune system is AIDS (Acquired Immune Deficiency Syndrome). The cause of AIDS is not fully understood, but it is believed to be a virus (below left). This virus enter the cell and alters its fuctions in such a way that it becomes confused. The infected cell does not recognize the body's tissue as 'friendly', and so attacks it as it would a germ.

At present there is no cure for AIDS, so the most important thing is to prevent the spread of infection in the first place. AIDS can enter the body only via the blood or during sexual intercourse. Intra-venous drug abuse carries a high risk. People should never inject themselves, unless they have a medical reason (for example if they are diabetic). Doctors advise the use of a condom during sexual intercourse, and the fewer sexual partners the better. Aids takes about six months to develop to the stage where it can be detected.

body, where it is called ringworm. Minor conditions such as these are easily treated, but prevention (in this case keeping your body clean and dry) is the best practice.

Dirty water

Protozoa are the simplest organisms in the animal kingdom. In many developing countries, where water hygiene is often poor, they cause much illness because they thrive in unpurified water. Protozoa are unicellular (they are made of one cell) and range greatly in size from microscopic (0.005 mm) to the size you can actually see.

The amoeba is a protozoan commonly found in ponds or slow-running streams. When water infected with amoebas is drunk, these protozoa enter the host and set up home in the gut. One such amoeba causes dysentery in humans. Once inside the host's gut, it starts to become active, irritating the tissue and upsetting the normal gut function. Dysentery results in stomach pains with diarrhoea, which can lead to dehydration.

In countries where medical care and pure drinking water are not easily available, dehydration is a most serious symptom. If more than 15 per cent of your body fluid is lost you will die. Drinking water infested with protozoa is a common cause of a usually mild form of dysentery called 'holiday tummy'. Dysentery can be prevented by purifying drinking water with chemicals or by boiling.

Parasites are another common cause of disease in the developing world. They live on or in other living organisms and feed on them. Most parasites live a very complicated life cycle. Schistosomiasis, for example, found mostly in central Africa, spends part of its life in freshwater snails. It lays eggs, which hatch into a free-swimming form. These leave the snail and may infest humans.

Fever bug

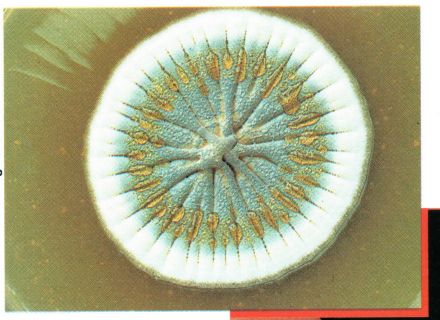
Swimming parasites can enter the body via the soles of the feet. Once inside the body, they continuously reproduce. After about six weeks, the victim develops a fever accompanied by a cough, pain in the joints and swelling of the liver. Newly formed eggs are excreted and voided by the victim (in urine and faeces) and these eggs enter the water and reinfect the snails.

Germ patrol

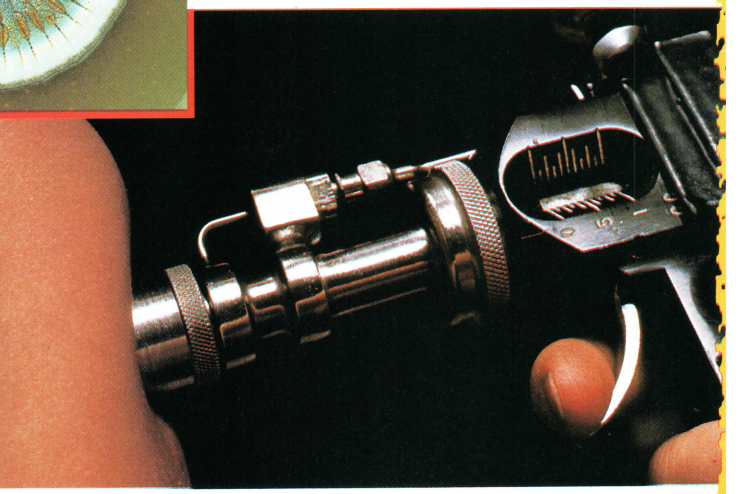
White blood cells are designed to destroy any germs that enter our bodies. Certain white blood cells – the T and B lymphocytes – work together to produce antibodies. These antibodies attach themselves to the specific germ they have been made to attack. That is why a BCG immunization for tuberculosis makes you immune to tuberculosis bacteria. Your body has produced antibodies to the very small dose of TB bacteria in the immunization and will now remember how to make it.

Prepared

If you come into contact with that type of bacteria again, your immune system will be armed and ready for it with the correct antibodies. Once the antibodies have been made, they are recognized by the lymphocytes, which pick them up and engulf them. But because the antibodies are attached to the germs, the lymphocytes also engulf and kill the germs in the process.



Andrew McClenaghan/SPL



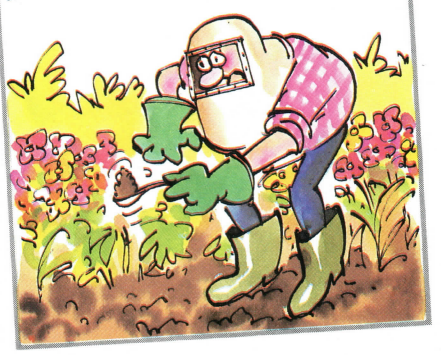
Steve Niedorf/The Image Bank

***A gun device** is used to spray accurate doses of vaccination through the skin. The dose helps the body to fight diseases. Penicillin, produced by the penicillum mould (above), is an antibiotic that acts against bacteria.*

Just amazing!

POWER IN NUMBERS

THERE ARE ABOUT 1,000 MILLION BACTERIA IN JUST 1 GRAM OF SOIL – LESS THAN ¼ TEASPOONFUL. GIVEN FOOD AND WARMTH, THEIR NUMBER CAN DOUBLE IN 20 MINUTES.



Paul Raymonde

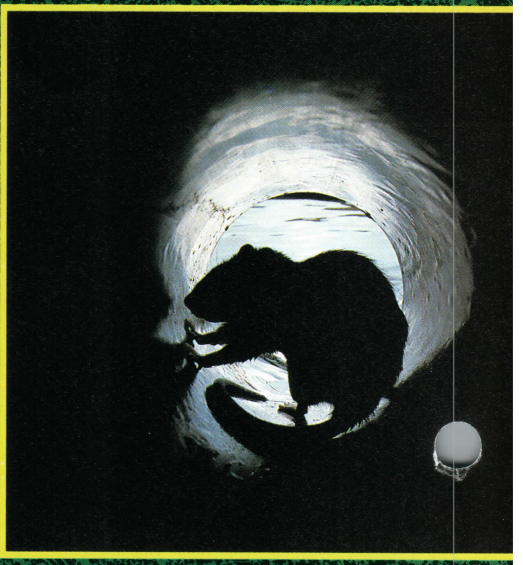
Harold Schultz/Bruce Coleman Ltd

Parrots and parakeets *are the main sources of psittacosis (an infectious disease), but about 70 species of birds are carriers of it.*

Dr Jeremy Burgess/SPL

Bluebottles *lay their eggs on uncovered raw meat, so the larvae have food when they hatch. The flies come into contact with many sorts of germ, which they spread.*

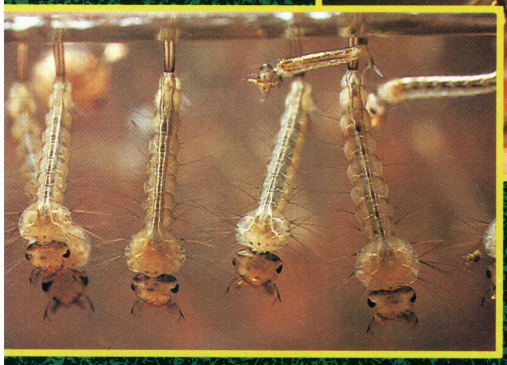
The rabies virus *attacks the nervous system of wild animals and dogs, which can pass it on to humans.*



Stephen Dalton/NHPA

Rodents and their fleas *carry the bacteria that cause plague in humans. Sewer rats are especially infested.*

Mosquitoes *are carriers of the bacteria that cause malaria. They lay eggs in pond water, where the larvae (below) develop.*



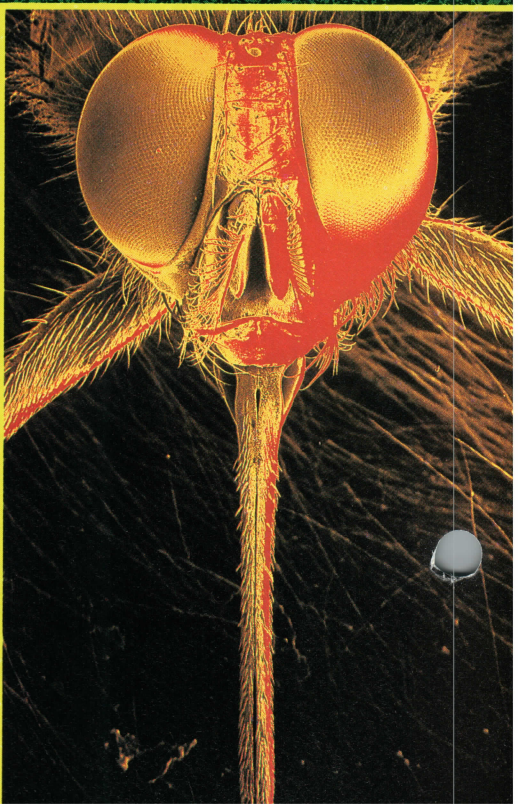
John Walsh/SPL

A pair of blood flukes *(the male is thicker); these can live in the intestines of human beings and cause dysentery.*

Martin Dohrn/SPL

A horsefly *bites through skin with scissor-like jaws. All sorts of germs survive in the blood it draws and are passed on to its next victim.*

Sinclair Stammers/SPL



Dr Jeremy Burgess/SPL

The African tsetse fly *– a large blood-sucking fly – carries the germs that cause sleeping sickness*

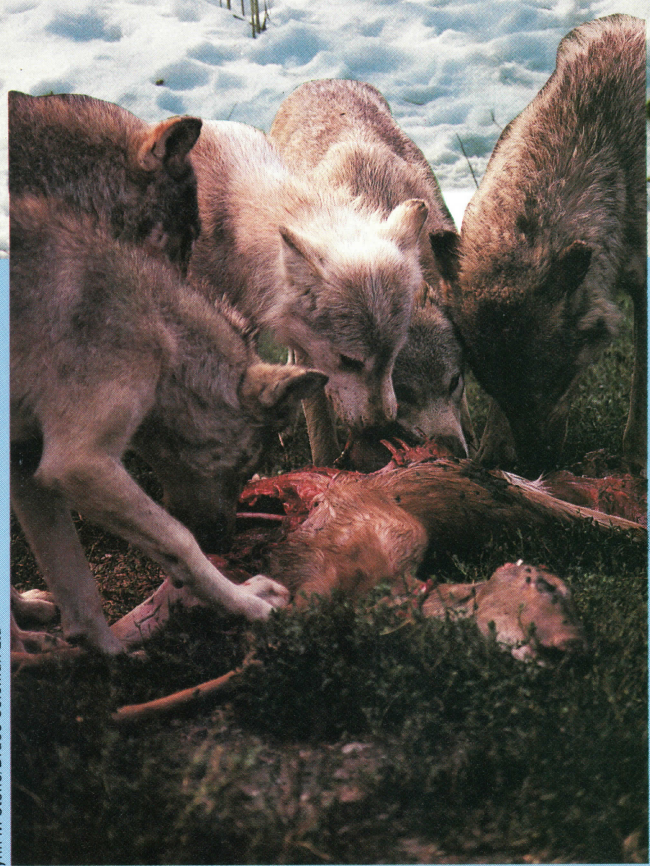
ZEFA

THE FIGHT TO SURVIVE

- TERRITORIES
- PREDATORS
- SHELTER

THE INSTINCT FOR SURVIVAL is shared by all animals, including ourselves. To survive, we all need food, shelter, the ability to avoid other creatures who might harm us and the means to reproduce our own species. These basic needs shape us and the world in which we live.

Of all an animal's basic needs, food is the most important. To ensure a supply of food, most creatures stake out an area of land – their territory – which they defend against other animals, usually of the same species.



Lynn M Stone/Bruce Coleman Ltd

***Wolves kill** to get food and in self-defence. Deer are typical prey. An adult deer may be several times the size of one wolf, so the wolves hunt in a pack, bringing down a deer that is too young, old or feeble to defend itself or get away. The number of wolves in a pack is about 20 – including a dominant male and female pair, cubs and related adults.*

Udo Hirsch/Bruce Coleman Ltd

Staking a claim

An easily spotted example of territorial behaviour is that of the robin. a robin will mark out a feeding area about the size of two back gardens and defend it vigorously against any intrusions by other robins. Individual robins patrol their territories regularly, announcing their ownership by singing. On meeting an intruder, the robin will attempt to frighten it away by a display of aggression, only resorting to fighting if all else fails.

Another easily observed example of territorial behaviour is that of the domestic cat. The cat uses scent, spraying strategic points with a mixture of urine and musk produced from a special gland at the base of its tail. Cats performing this kind of marking dance up and down on their back legs, their tails straight up, as they eject the scent marker. Both male and female cats indulge in this activity, although the scent from the tom, the male cat, has the stronger smell. Scent marking (through the use of the special scent glands, urine or dung) together with sound and visual displays are the main ways in which animals mark out their territories.

While most animals defend their territories against others of their own kind, they are quite willing to share space with other species who do not eat the same sorts of food and do not present a physical threat. A robin will chase off other robins but will ignore birds such as sparrows, finches and tits, that it does not consider a threat.

Not all animal territories are fixed. On the great grasslands of central Africa, animals such as wildebeest and zebra migrate thousands of

***A giraffe** guards her calf against a group ot lionesses. It is the lionesses who usually do the hunting, taking the meat back to the rest of the pride.*

Jonathan Scott/Planet Earth Pictures

kilometers each year to areas where the grasses they eat are growing at particular times. They travel in great herds; if a predator approaches, say, a herd of zebra, the herd will close up and in the confusion it is less likely that one zebra will be singled out and killed. Mammals, birds and fish all use this technique of massing together to confuse predators.

Kenneth Lucas/Planet Earth Pictures

Hunting in packs

Many hunting animals — lions and wolves, for instance — work in packs to deal with quarry that behave like this. In North America, wolves prey on elk and bison. During the chase, relays of wolves take over from one another in order to exhaust the victim and not themselves.

Some creatures store food against hard times. In northern Europe and North America, squirrels stockpile nuts and grains to see them through the winter months to the following spring. Foxes, hyenas and wolves will bury part of their latest victim as an emergency store of meat, in case it is a while before the next kill. Hedgehogs gorge themselves during the summer and autumn to build up reserves of fat, on which they live during their winter hibernation.

Deep sleep

Hibernation is a very effective method of surviving the cold of a long winter and the lack of readily available food. When hibernating, an animal's body behaves as though it were in a very deep sleep, with heart and breathing rates at the minimum necessary to maintain life. In this state, the animal's bodily functions can be fuelled from the fat store built up during the summer, the fat also being very good insulation against the cold.

Hamsters build up a store of food for the winter — as much as 15 kg in weight — then go into a cycle of partial hibernation, when the temperature drops to 4°C and below. Every five days or so, they wake up for a meal.

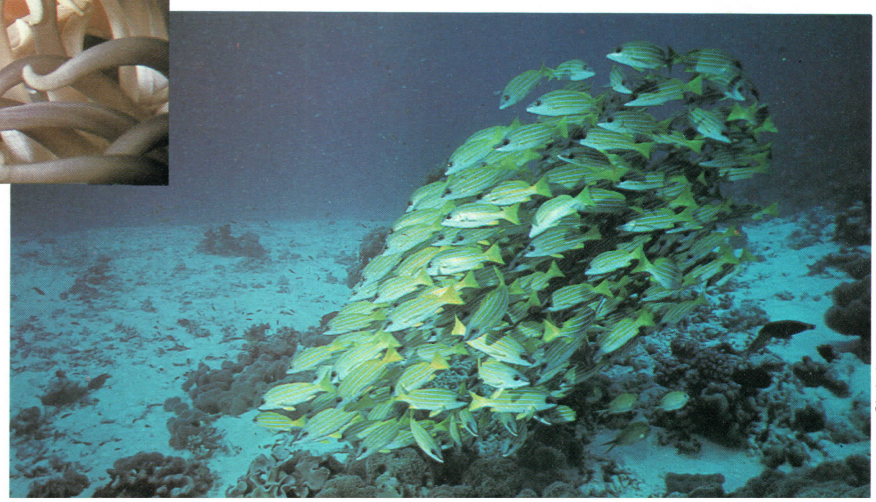
Shelter is almost as important as food in the survival game. Animals need some place to escape from

***An elf owl** has taken over a nest hole in a cactus plant. The hole was probably dug out of the cactus by a woodpecker. When the hole was originally pecked, its inside dried out and became impermeable, so that the cactus should not lose any essential water through the hole.*

Jen & Des Bartlett/Bruce Coleman Ltd

***A sea anemone** acts as protector and provider for a pair of clown fish which are immune to its stinging tentacles.*

***A school of snappers** confounds a predator by keeping together so that it is difficult to single one fish out for the kill.*



Christian Petron/Planet Earth Pictures

***A robin's** territory may extend over one or two gardens. The robin regularly visits certain observation points. It will chase away or even attack another robin, but allow other birds to feed. A robin will hover around a gardener, ready to eat grubs and other titbits found in freshly dug earth.*

Peter Hinchliffe/Bruce Coleman Ltd

predators and weather as well as somewhere to rear their young.

Animal homes come in an amazing variety – from the bare earth which serves as a nest for the Arctic skua, to the 'mobile homes' of snails, to the 3-4 metre high 'skyscrapers' built from mud and excrement by termites.

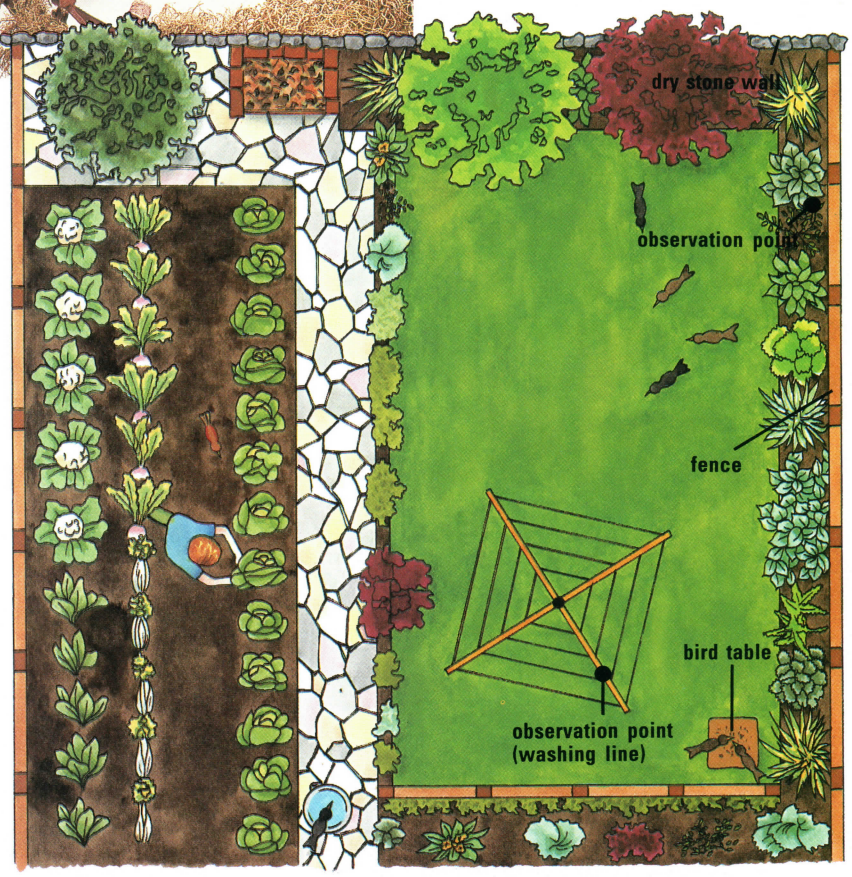
Living underground

Burrows dug into the ground are a very common form of home for mammals. A typical warren has many tunnels and entrances. Badgers live in underground 'sets'. Badger sets can be lived in for many years, by generation after generation of the same family or 'clan'. One set in Gloucestershire, England, is thought to be over two hundred years old.

Some birds use burrows to nest in. The puffin builds a nest chamber at the end of a 3 metre-long tunnel, either digging the burrow itself or using an abandoned rabbit warren. Sand martins drill 1½ metre nest burrows into the banks of rivers, lakes and ponds. More conventional bird nests come in all shapes and sizes. The house martin, a close relative of the sand martin, builds with clay, sticking the nest to the walls of buildings, under the eaves.

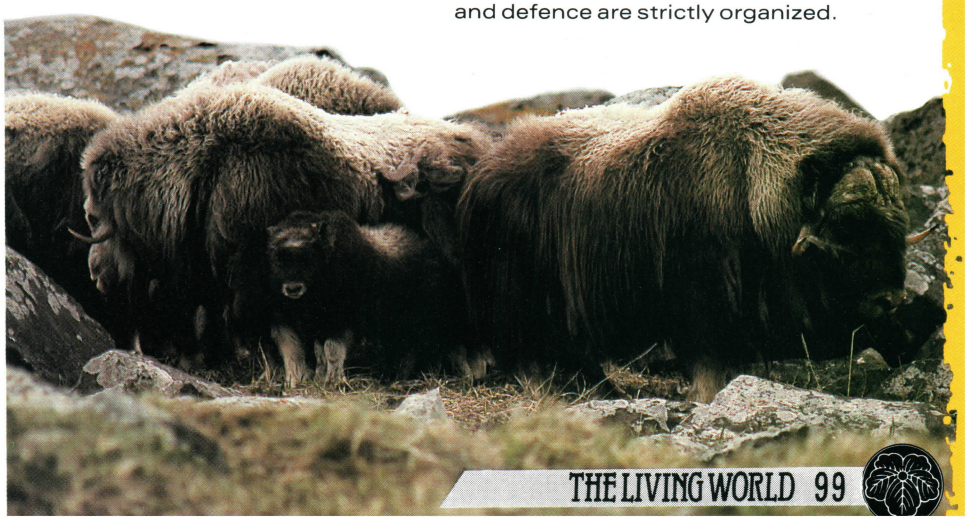
The African weaver bird, as its name suggests, weaves a nest from long grasses. Looking for all the world like a plant holder, weaver nests are suspended from tree branches – they display a dazzling level of skill in their construction.

However, the true architects of the living world are ants, termites, bees and wasps. All of these are 'social' insects – they work collectively to serve 'queens' who have given rise to the whole of the colony. Within their world, duties such as food collection, feeding of the young and defence are strictly organized.



Caroline Brodie

***Musk oxen** threatened by predators form a circle with the adults with their massive horns facing outwards and the weaker young in the centre.*



Francisco Erize/Bruce Coleman Ltd

THE GUARD DOG

Trevor Wood

Today's domestic dog is a descendant of the wolf and shares some of the wild animal's instincts. Wolf packs have a central den – a safe place the pack protects from outsiders. Trespassers are attacked and driven away. All dogs have this same instinct. They establish a territory – usually the home of their owner – and will defend this area against intruders. Special breeding has accentuated this instinct in guard dogs such as Dobermanns (pictured above).

Francisco Erize/Bruce Coleman Ltd

A brown skua *snatches a penguin chick on the Falkland Islands in the South Atlantic. Penguins have few enemies except the skua, the leopard seal and Man. Skuas will eat anything from worms to small birds and mammals.*

To accommodate such rigid societies, these insects build marvellously complex homes with large numbers of different 'chambers' allocated to specific purposes, such as cell-like structures designed to house the developing eggs. Bees also build similar structures for storing food – these are the honeycombs containing nectar, honey or pollen.

Outside the home, animals frequently use camouflage or some form of defensive system to survive or prevent attacks by predators. In terms of protection, a familiar example is the snail's shell. When threatened, the snail withdraws its fleshy body parts into the shell until the threat has gone away. The snail's shell also helps it to keep moist – vital for its survival.

Higher up the evolutionary chain, creatures such as porcupines and hedgehogs have evolved defensive spines which they can erect when under attack. These spines have developed from hairs and are raised by an increase in blood pressure. Rolling into a ball protects the animal's underside and makes it virtually invulnerable to attack.

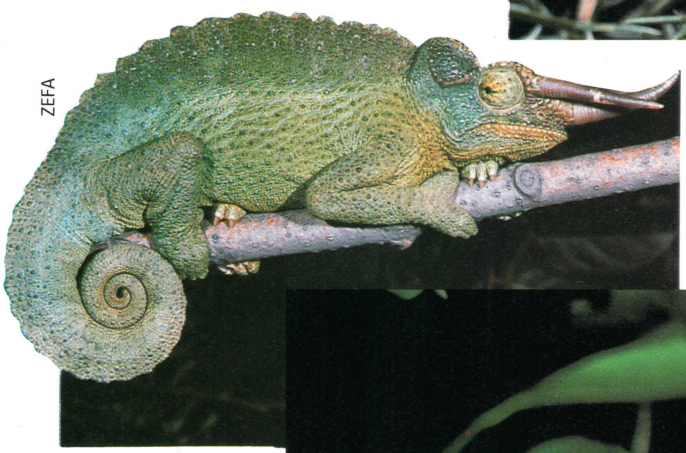
When a cat is angry, its fur bristles and it arches its back. All this is done to make it look as frightening as possible to an opponent. This is a common defence in nature. Many moth and butterfly species use flash colour and striking wing designs to frighten off predators. Some even squeak.

The use of colouring as camouflage is very common and can be seen in insects, fish, birds and mammals. Few animals can match the chameleon, which can change its colour to match its background.

Camouflage is not just used for defensive purposes – predators use camouflage, too. If you look carefully at a lion, you will see that the stomach fur is a lighter colour than that on its back. This is to minimize the contrast between those parts of the body which are in shadow and those which are in light. This makes the lion's body appear 'flatter' than it really is and, therefore, more difficult to see.

Adrian Davies/Bruce Coleman Ltd

The emperor moth *frightens off its enemies with spots on its wings that resemble large staring eyes.*



ZEFA

Gunter Ziesler/Bruce Coleman Ltd

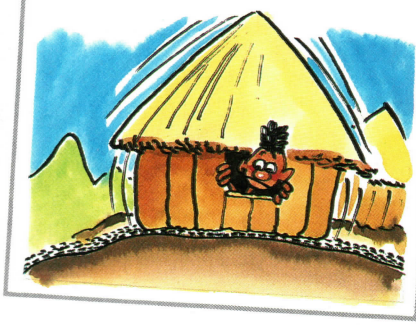
A chameleon *can change colour in minutes, depending on species, to blend in with its surroundings. This not only protects the chamelion, but also allows it to creep up on prey undetected.*

Less common than colour camouflage is the ability to look like the plant on which the animal lives. A very good example of this sort of camouflage is the stick insect which, when still, is almost impossible to tell from a twig. Different sub-species of this insect have evolved so that they look like the particular plants on which they live. But once spotted, a stick insect will try to frighten the attacker away. One sub-species imitates a scorpion, grabbing with its front legs and curling its abdomen upwards, like a scorpion's stinging tail.

Just amazing!

SOLID FOUNDATIONS?

A VILLAGE IN AFRICA IS BUILT ON TOP OF A MOUND 100 METRES ACROSS – CONSTRUCTED BY A COLONY OF TERMITES.



Paul Raymonde

THE UNDERWORLD

Adrian Warren/Ardea London

- EARTHWORMS
- MOLE HOLES
- SAFETY UNDERGROUND

THE EARTH BENEATH OUR feet is teeming with life. Some 20 million species live in the surface soil. These vary from microscopic animals, plants and bacteria, to larger burrowing animals such as insects and mammals.

Bacteria are by far the most common organisms living in the soil. There can be as many as one thousand million of them in a gram of earth. Different types of bacteria perform different tasks. For example, nitrifying bacteria help to break down the nitrogen-containing chemicals in dead organic matter into nitrates, which can be absorbed by plants. Nitrogen-fixing bacteria live in the roots of peas,

Vampire bats *live in huge swarms in caves in the southern parts of South America. At night, they fly out in search of large, warm-blooded animals. When they find one (inset), they pierce its skin and lap, rather than suck its blood.*

Gunter Ziesler/Bruce Coleman Ltd

clovers and other leguminous plants. They convert nitrogen in the air into a form that nitrifying bacteria can then turn into nitrates.

Fungi in the soil live on both living and dead animals. They, too, break down organic material to provide nutrients for plants.

There are also a large number of animals that live in the earth, such as worms, mites, spiders, beetles and slugs.

Eating soil

Earthworms are one of the animal species inhabiting the soil that are most often seen. More than two hundred species of worm live in Europe. All of them live by burrowing in the soil and eating soil. They digest the organic material in it and excrete the rest as soft wormcasts, within the soil or on the surface, depending on the species. Several species of worm plug the tops of their burrows with leaves.

As many as 500 worms may make their home in a square metre of soil. Their constant burrowing allows air into the soil which is vital for plants to grow. Minute bristles on their bodies help them burrow through the soil.

You can chop an earthworm in half without killing it. The missing ends will simply regenerate and you will end up with two worms rather than one. Earthworms are also hermaphrodite. That is, they are both sexes at once – male one end, female the other.

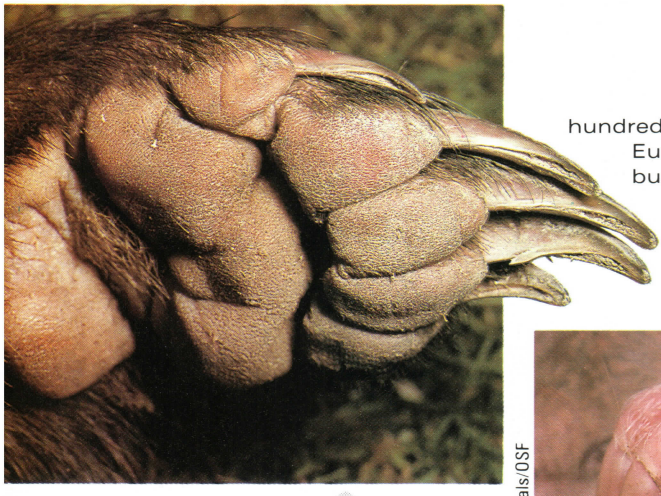
Worms rise to the surface when it rains or when the dew settles in the morning, otherwise they would drown. There, they are very vulnerable to birds and hedgehogs, which eat them. Some birds drum their feet on the ground, to make worms think it is raining. Below ground, moles are their only enemies.

The mole is a fast, tireless digger and the shape of its body is well

David Fox/Oxford Scientific Films

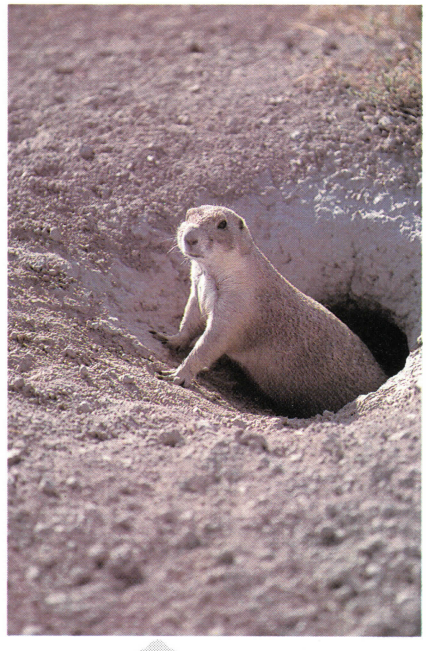
***The mole** uses its extra-wide forelegs and powerful claws to shovel earth round behind it. Its snout is extremely sensitive to smell and vibrations of worms and insects in the soil.*

ZEFA



R. Mendez/Animals Animals/OSF

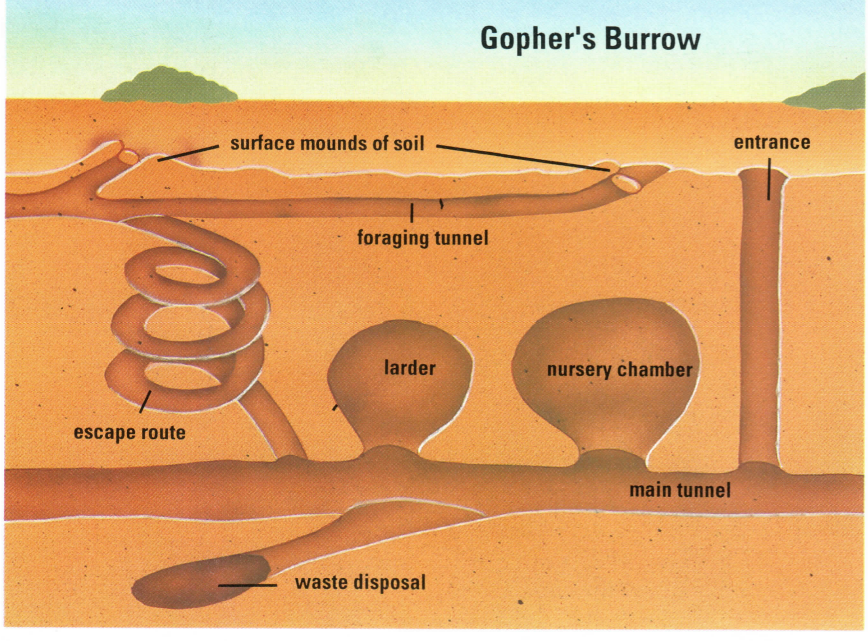
***Powerful claws** are needed if you are going to burrow through the earth. The badger and the gopher (right) have hooked claws and curved palms to help them shovel earth.*



John Mason/Ardea London

***A blacktail prairie dog** guards the entrance to its underground colony which may house hundreds.*

***The North American gopher** leads a solitary life. This extensive burrow houses just one female and her young – and contains everything they need to survive.*

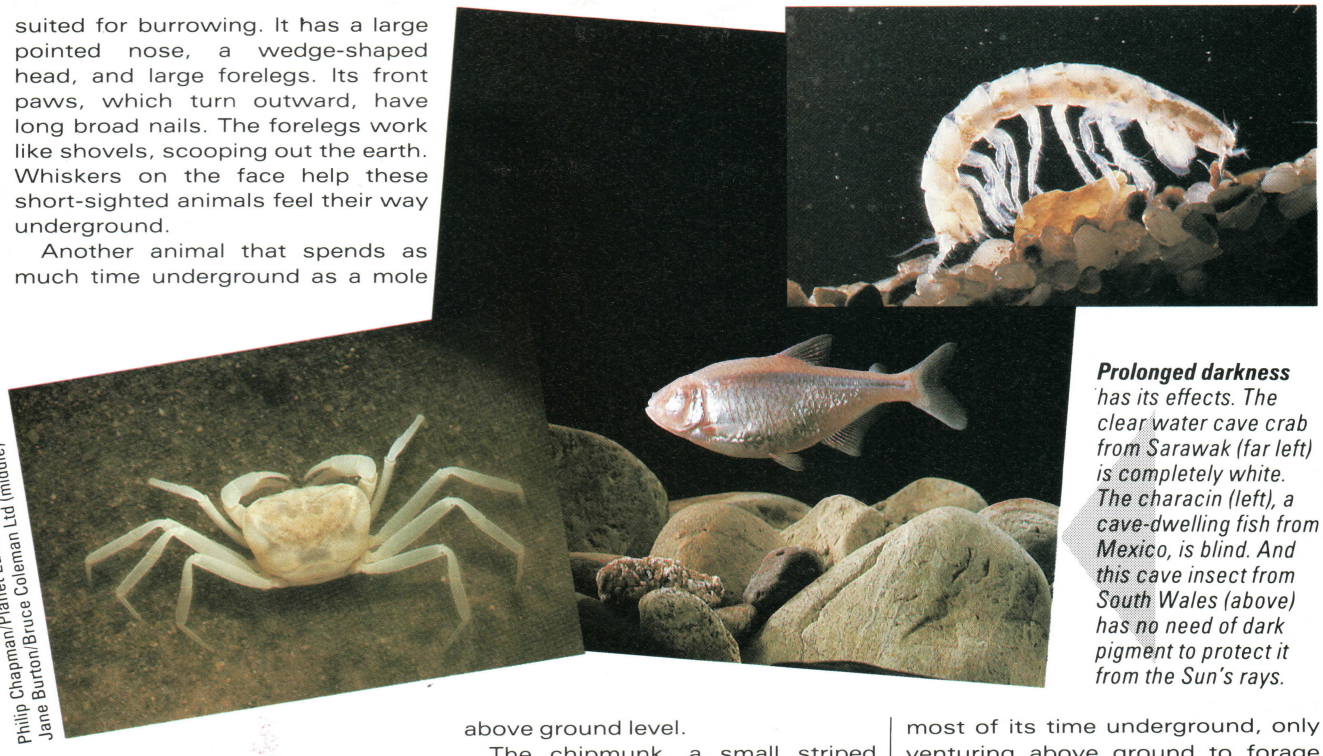


Mark Franklin

suited for burrowing. It has a large pointed nose, a wedge-shaped head, and large forelegs. Its front paws, which turn outward, have long broad nails. The forelegs work like shovels, scooping out the earth. Whiskers on the face help these short-sighted animals feel their way underground.

Another animal that spends as much time underground as a mole is the North American gopher. These small animals live in long tunnel complexes from which they seldom emerge. They dig their tunnels with the large claws of their front feet and also their front teeth.

Gophers spend much of their time patrolling their tunnels which can be as much as 240 metres in length. They do not like other gophers entering their homes except during the breeding season. A nearly hairless highly sensitive tail allows the gopher to feel its way backwards through its tunnels.



Chris Howes/Planet Earth Pictures

Philip Chapman/Planet Earth Pictures
Jane Burton/Bruce Coleman Ltd (middle)

Prolonged darkness *has its effects. The clear water cave crab from Sarawak (far left) is completely white. The characin (left), a cave-dwelling fish from Mexico, is blind. And this cave insect from South Wales (above) has no need of dark pigment to protect it from the Sun's rays.*

Muskrat burrows

The North American muskrat lives in burrows in the banks of streams. Muskrat houses usually have more than one underwater entrance as well as an entrance situated above ground level.

The chipmunk, a small striped animal that lives in burrows in Asia and North America, also makes distinctive homes. It digs two tunnels which meet underground in a large nesting area. The soil is pushed out to plug the entrance to one of the tunnels, which is only used in an emergency.

Sets are the burrow homes of badgers, whose strong front claws and powerful bodies make them efficient tunnellers. These sets are usually no more than two metres underground and, once dug, they may be used for centuries by generations of badgers.

The pink fairy armadillo is also a formidable burrower. It makes its burrow by digging with its front legs and pushing with its snout. A native of South America, it spends most of its time underground, only venturing above ground to forage for insects.

Large numbers of prairie dogs live in underground colonies, or 'towns'. Prairie dogs are not actually dogs but members of the squirrel family. Their name comes from their distinctive, shrill, dog-like bark. Several thousand – or even a million – prairie dogs may live together in a colony. This is divided into wards, which in turn are divided into family groups, or coteries. Each coterie has an entrance tunnel that goes down around four metres to a series of burrowed rooms for sorting food or sleeping in. The advantage of this communal living is that lookouts at the tunnel entrances can warn of danger. A high-pitched bark alerts the others to dive underground.

The naked mole-rat *from East Africa is literally naked. It needs no fur to keep it warm – or to protect its skin from the Sun's rays. Its protruding front teeth are used to help it burrow through the hard earth from which it rarely emerges.*

Jane Burton/Bruce Coleman Ltd

Paul Raymonde

Most rabbits live in burrows that they did not actually dig. Whenever possible, they tend to move into those abandoned by badgers, prairie dogs, skunks or woodchucks. Rabbits do burrow though, extremely well, and use their skills to extend homes they have found. A large rabbit warren may house as many as 400 rabbits with some 2,000 entrances. Tunnels within the warren can act as roads, places to sleep or places to rear young.

Trapdoor threat

Tarantulas are the world's largest spiders and many types of them dig burrows as nests. One variety, the trapdoor spider, digs a tunnel and covers it with bits of moss and silk webbing.

When an unsuspecting insect walks too close, the spider flips the trapdoor open and captures its prey. The burrow, which can be 25 cm deep, is also used for protection and as a nest for young spiders.

Hamsters burrow underground homes where they hoard vast quantities of nuts, seeds and roots.

Buried in sand

Some cockroaches burrow in sand, soil and rotting wood with their strong and short legs. Crickets burrow small tunnels which can provide shelter and a place to lay eggs. They also feed on the roots and tubers they find while digging.

Desert vipers trap their prey by lying in wait under the sand with only their unblinking eyes visible.

Camel crickets in the south west of America have basket-shaped clusters of spurs on their hind legs to help them dig into sand dunes. Sand in American and African deserts is also the home of desert-living grasshoppers that exhibit a type of behaviour known as 'self-burial'. Rather than make an elongated burrow, the grasshopper rests on the surface of the sand and moves back and forth until it has submerged itself. The aim of this strange behaviour is protection.

Sleeping frogs

Several species of frog live deep under the desert. On the rare occasion it rains, they emerge and lay spawn in pools of water. The spawn changes via metamorphosis into frogs in weeks. When the pools dry up, the frogs go underground again and lay dormant – sometimes for years – until it rains again.

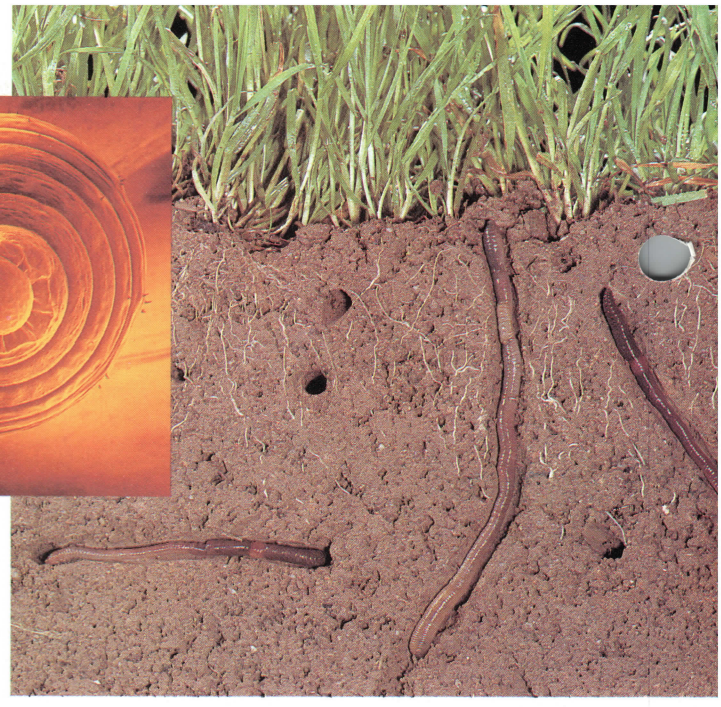
Hedgehogs and dormice find underground burrows to hibernate in for the winter. Their body temperature drops and their metabolism slows down to conserve energy. What energy they do need is provided by their fat stores.

Jan Taylor/Bruce Coleman Ltd

The trapdoor spider *puts a lid over its burrow. When prey passes, it flips the lid open to seize the unsuspecting insect.*

Jan Taylor/Bruce Coleman Ltd

David Scharf/SPL



Jean-Paul Ferrero/Ardea London

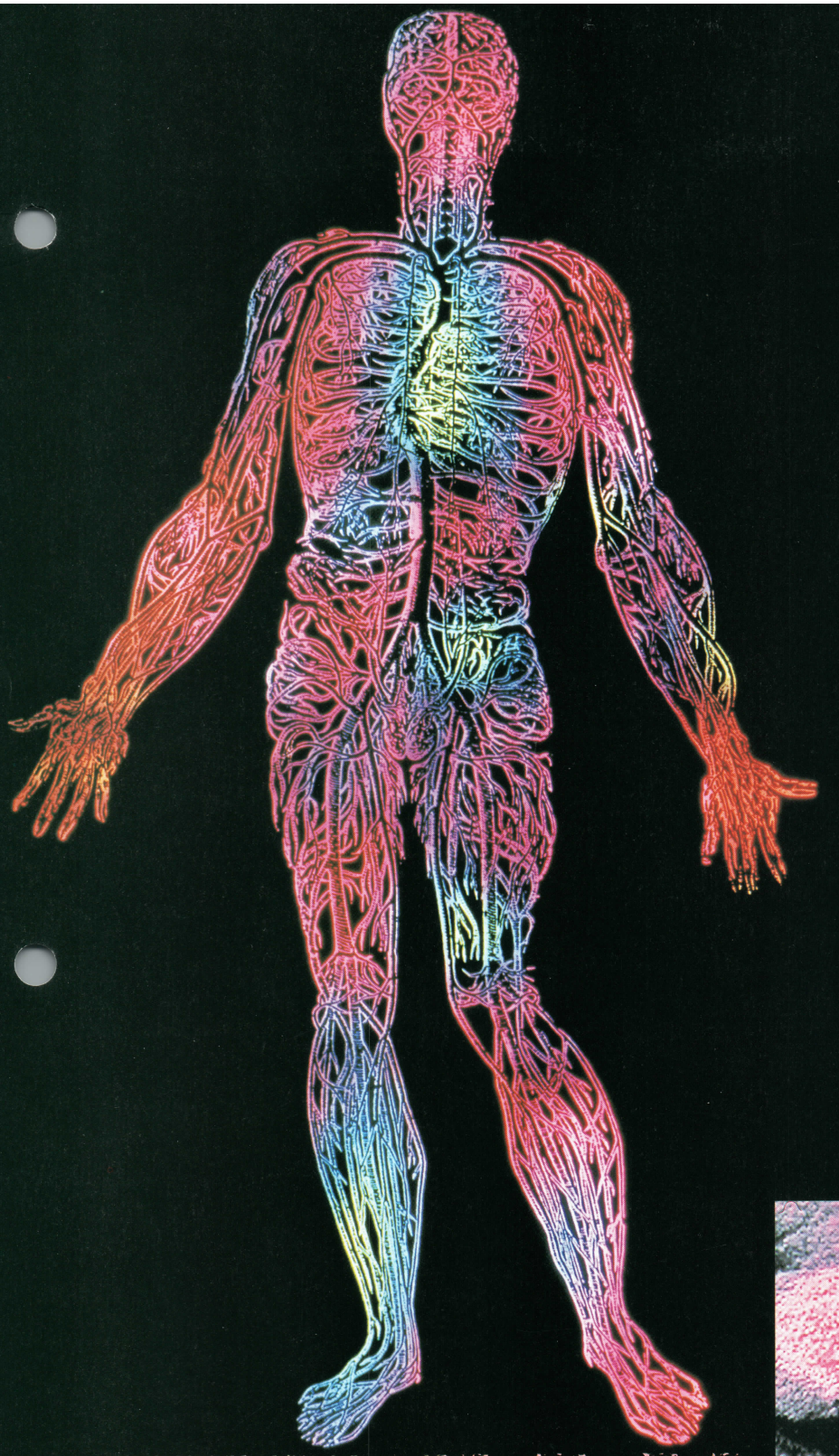
Earthworms *head for the surface when it rains, so that they do not drown. The worm's mouth (inset above) swallows the soil.*

Sean Morris/Oxford Scientific Films

The spider *then emerges to drag the insect back into the lair, where it is devoured at leisure.*

Mantis Wildlife Films/Oxford Scientific Films

A type of tarantula *– the largest of all spiders – the trapdoor spider is found mainly in East Africa and throughout Western Australia.*



HUMAN MACHINES

- MOVEMENT
- THE SENSES
- CONTROL CENTRE

THE HUMAN BODY IS A better machine than any engineer can design. Athletes can develop their bodies to sprint at about 50 km/h, bowl or throw a ball at more than 140 km/h, jump to heights of 2½ metres, yet retain the precision, should they wish, to thread a needle.

The body is made up of a number of maintenance and performance systems that have evolved through millions of years. The circulatory system, for instance, is a remarkably compact network of vessels which carry blood around the body. In this network there are about 37,000 km of capillaries, veins and arteries. Blood is pumped from the heart at the rate of 5½ litres a minute when the body is relaxed and up to 17 litres a minute during vigorous exercise. During a lifetime the heart may pump 2,000 million times without missing a beat – a feat of design well beyond the best of today's engineering.

Muscle power

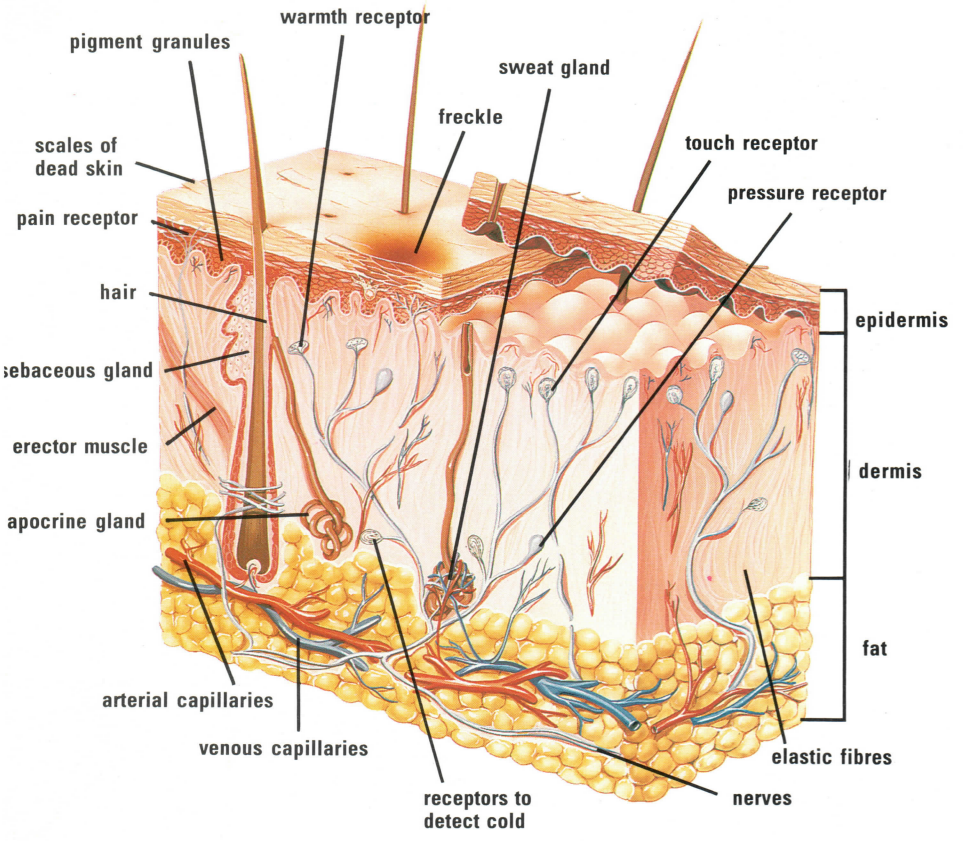
Muscles account for about 30 per cent of the human body and provide power for the body to move – from the precision actions of the hand during writing, to the explosive flexings of the leg muscles during

Mehad Kolyk/Science Photo Library

***The circulatory system** is a network of branching blood vessels that carry blood pumped by the heart to the tissues around the body.*

CNRI/Science Photo Library

Structure of the Skin



The skin *is the largest organ of the body. It helps to regulate body temperature, and it contains the receptors that give the sense of touch.*

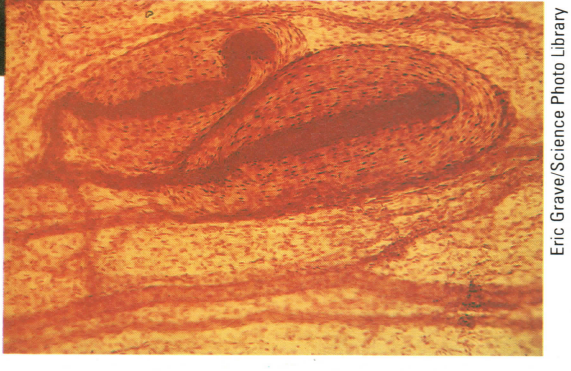
running. There are more than 600 voluntary muscles which receive instructions from the brain to carry out functions such as running, jumping, walking, and blinking.

Involuntary muscles are vital to maintain body systems. For example, the heart is a muscle which pumps blood through the body; chest muscles and the diaphragm expand the chest cavity to aid breathing; and muscles in the uterus help in the birth of a baby.

Muscles are biological machines, converting chemical energy from food into mechanical energy to produce movement. Even the most unfit person can generate several kilograms of force across each square centimetre of muscle, and the muscles at the back of the hip can generate well over 1000 kg.

Zefa

The human hand *has a complicated arrangement of bones, joints and ligaments that, together with the use of touch-sensitive cells (right) in the skin, enable it to grasp and lift large, heavy objects or to manipulate tiny objects, such as a needle and thread.*



Eric Grave/Science Photo Library

Relaxers

The muscles are made up of thousands of parallel fibres which contract by a small amount when they receive a signal from the brain. The effect of the combined contractions is to shorten the muscle, which pulls on the tendons to move the limbs.

Two sets of muscles work on the same limb – one contracting while the other relaxes to bend it. To straighten the limb, they reverse roles – the one that was contracting now relaxes while the other goes into contraction.

The joints between bones enable the muscles to provide controlled movement. There are more than 200 joints with varying degrees of movement. The shoulder joint, which has a ball-and-socket design, affords the arm a lot of movement in all three planes, whereas the ankle can move in only one plane. The range of movement of each of the 100 or so vertebral joints in the spine is also small, but they act in combination and enable the back considerable movement.

Shock absorbers

Joints are more efficient and last longer than any machine equivalent. To reduce wear caused by friction, the knee, hip and ankle joints, for example, are held together by ligaments – tough fibres of collagen – and cushioned in a pocket of lubricating synovial fluid. This system of lubrication and suspension enables the body to withstand strenuous activity and stresses up to 20 times the force of gravity.

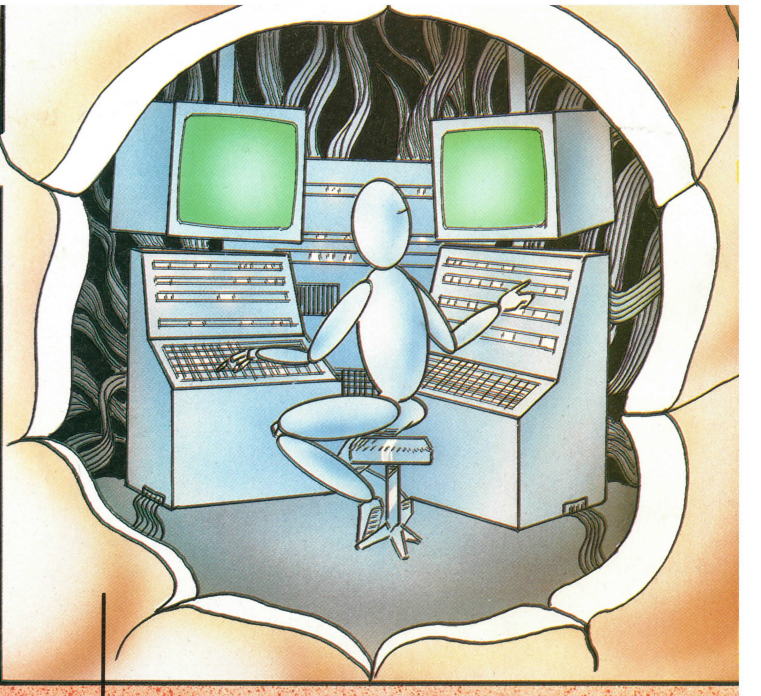
Sometimes, as the body ages, the joints do not work so smoothly and arthritis (inflammation of the joints) can set in, causing pain and difficulty of movement.

Mobility, however, depends not just on muscles and bones, but also on balance to co-ordinate movement. The inner ear is the organ of

Biophoto Associates/Science Photo Library

A single human taste bud, *photographed through a microscope, showing the cells that identify sweet, bitter, acid and salt.*

Anatomy of the Female Body



spinal cord

lungs

liver

stomach

large intestine

small intestine

muscle fibres

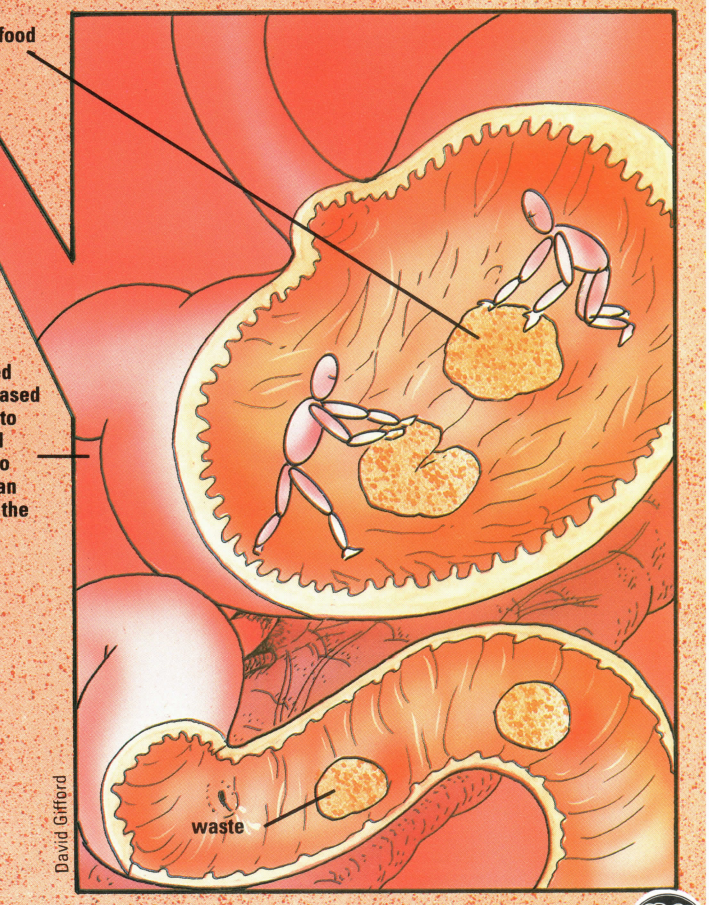
tendon

The brain works on two levels to control:
1. **involuntary functions, such as breathing and heartbeat, and**
2. **voluntary actions, such as contracting muscles to move the limbs.**

balance. It tells the brain, for example, which is up and which is down, the angle of the head and the direction of movement.

The angle of the head is detected by a number of small chambers within the inner ear which are lined with tiny hairs. On top of these hairs are crystals of calcium carbonate, which shift when the head moves. These shifts generate electrical impulses which the brain uses to work out the angle of the head.

There are also three bony, semi-circular, fluid-filled canals in the inner ear. When the head rotates or undergoes acceleration, the fluid

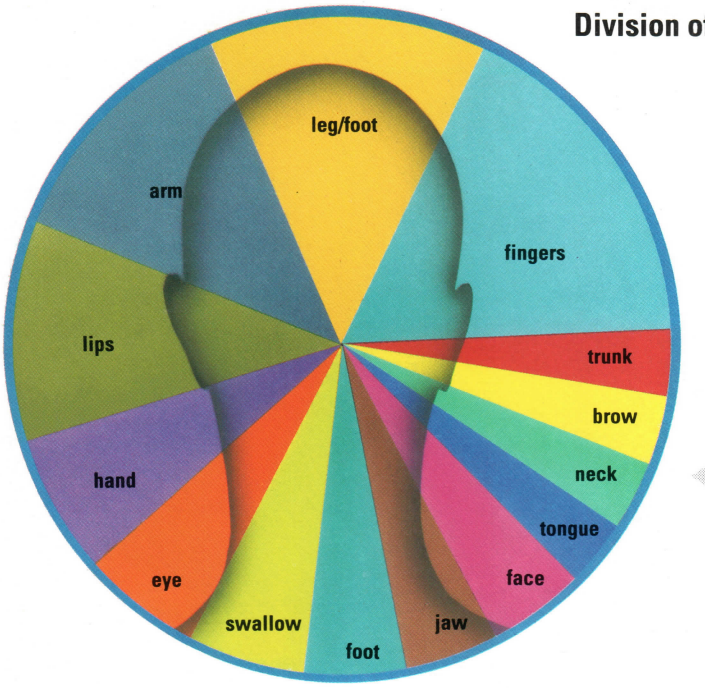


Substances called enzymes are released into the stomach to dissolve food and break it down into chemicals that can be absorbed into the blood stream.

The human body *is like a highly efficient chemical factory, with many processes, such as the digestion of food, under the central control of the brain.*

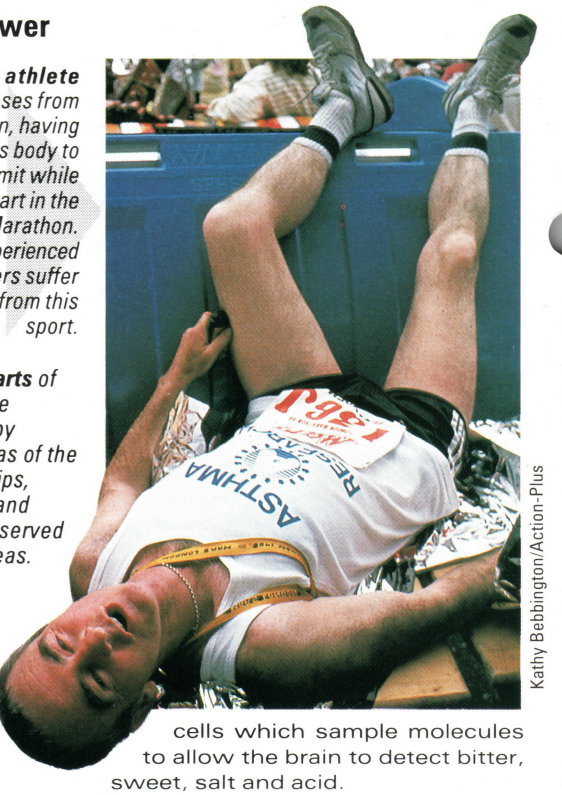
David Gifford

Division of Brain Power



An athlete *collapses from exhaustion, having pushed his body to the limit while taking part in the London Marathon. Many inexperienced runners suffer injury from this sport.*

Different parts *of the body are controlled by certain areas of the brain. The lips, arms, legs and fingers are served by large areas.*



Kathy Bebbington/Action-Plus

moves and triggers receptor cells in the canals to tell the brain the direction and speed of the head.

The ear can detect a wide range of sounds and distinguish between sounds that are only slightly different in intensity. The outer passage of the ear, or auditory canal, doubles the sound energy passing through it by targeting the sound on the ear drum. The sound then passes to the three smallest bones in the body which vibrate and amplify the sound another 30 times.

Once past the tiny bone network, the sound arrives at the cochlea – a fluid-filled, snail-shaped structure. The cochlea contains more than 20,000 hair cells, each of which may have 100 hairs protruding from it. These hair cells are moved back and forth by the sound waves passing through the fluid.

Different hair cells respond to different sound frequencies and each cell sends a message along the auditory nerve to the brain. The messages are decoded by the brain, which can detect the direction of a sound source by comparing the arrival times of a sound at each ear. The brain can judge the direction of the sound even though the difference in time of arrival at the ear may be only one hundred-thousandth of a second.

Mark Franklin

COMA

A coma is like a very deep sleep. It can be caused by severe illness, a drug overdose, too much alcohol or a head injury. A person in this state does not respond to any form of stimulus and cannot be awakened, often for long periods. The longest recorded coma is 37 years 11 days, which befell a 6 year old American girl, undergoing an appendix operation. She died, without recovering consciousness, in 1978.

Wrapped up

The largest organ in the body is the skin. It performs the important function of protecting and holding the body, and is an important point of contact with the environment. It is the organ of touch, containing sensitive cells which tell the brain the difference between hot and cold, wet and dry, soft and sharp, and can detect stimuli only 3 mm apart in the most sensitive areas, such as the finger tips.

The tongue, also, is covered by a sensitive layer containing receptor cells which sample molecules to allow the brain to detect bitter, sweet, salt and acid.

The sense of smell depends on yet another set of receptors. These are in the mucus-covered nerve endings which project from the lining of the nasal cavity. They can detect a single molecule.

The human brain is like a giant computer yet weighs less than 1½ kg. It contains roughly ten thousand million nerve cells, each of which can make 250,000 interconnections with other cells. The brain is the controlling centre for our thoughts, movements and body functions. It is isolated from the rest of the body by a protective barrier of fluid.

This protective barrier is provided by a wall of cells lining blood vessels around the brain. These cells regulate the passage of chemicals between blood and cerebrospinal fluid, which bathes the brain and keeps out bacteria.

SIAMESE TWINS

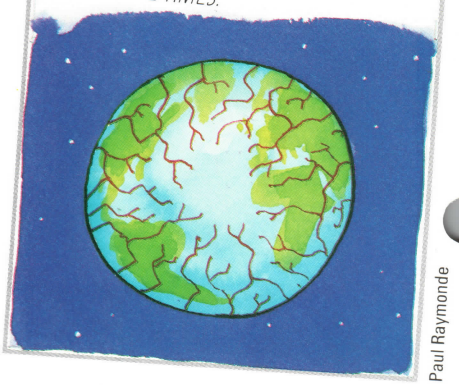
Gamma/Frank Spooner Pictures

Non-identical twins occur when *two* eggs are fertilized. Identical twins result when a *single* fertilized egg divides. An incomplete division produces Siamese twins. Some Siamese twins can be separated, but not Masha and Dasha, who live near Moscow. The sisters are two people and they each have a pair of arms, but their spines are merged into one, and they share just one pair of legs and one bowel.

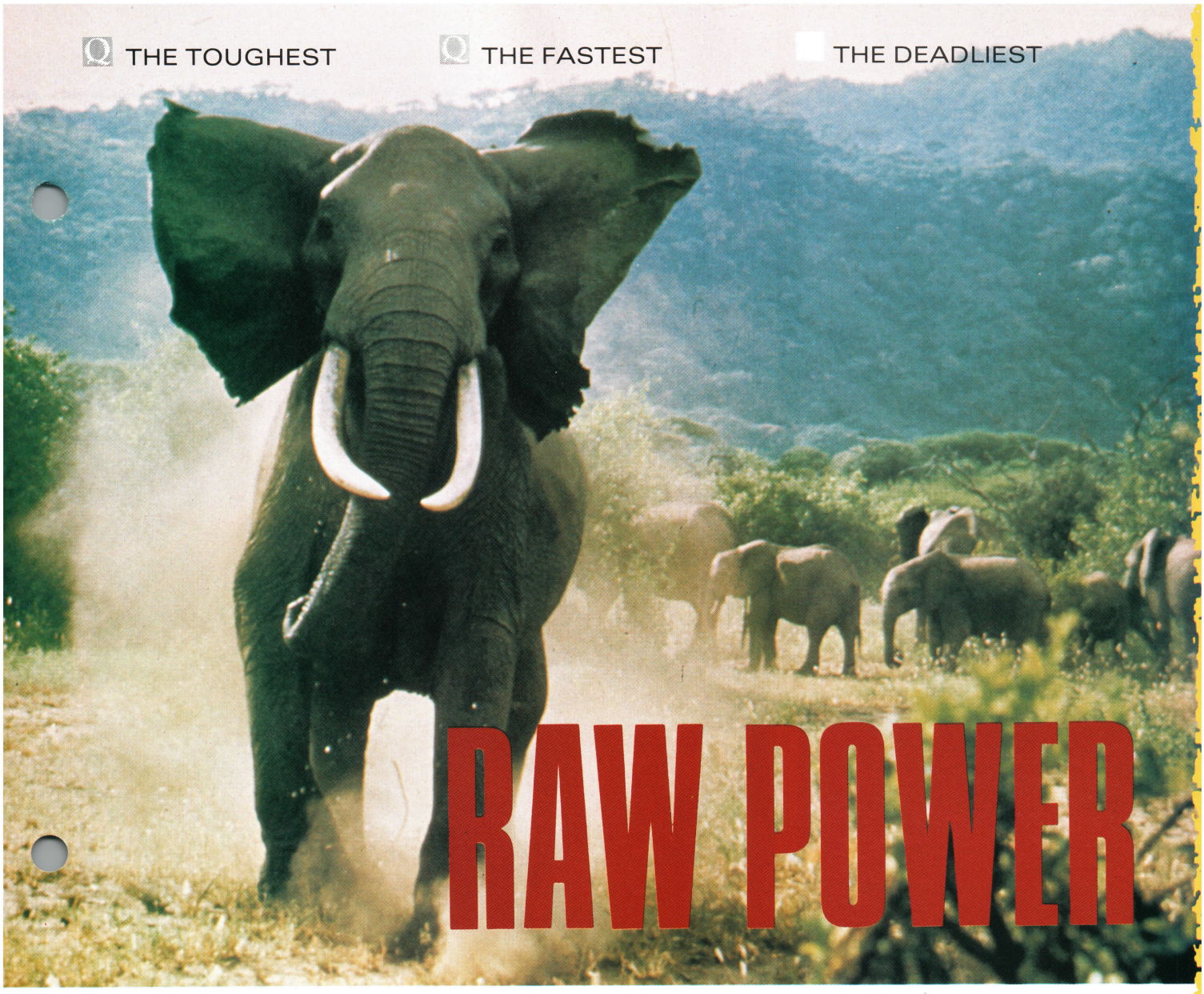
Just amazing!

BLOODLINES

IF ALL THE BLOOD VESSELS IN THE HUMAN BODY WERE LAID END TO END, THEY WOULD STRETCH AROUND THE EARTH FIVE TIMES.



Paul Raymonde



RAW POWER

Survival Anglia

THE STRONGEST ANIMAL IN the world is not the elephant. The dung beetle, found in the tropics, can support 850 times its own weight on its back – while an elephant can carry only a quarter of its body weight.

The elephant is not the biggest animal, either – the blue whale is the largest animal ever known to exist. It grows up to 30 metres in length and weighs up to 140 tonnes – about the weight of 30 full-grown elephants.

Tough guys

And you would think that an elephant is pretty tough, but not as tough as the larvae of the chironomid fly which can live at temperatures as low as −270°C and as high as 102°C. It is also the toughest animal – it can survive being totally dehydrated.

However, the elephant does have the distinction of being the largest living land animal. It can grow up to 4 metres tall at the shoulder, and the largest ever weighed over 12 tonnes. Tusks can grow up to 3.5 metres in length and weigh over 100 kg.

The largest crocodile, the Nile Crocodile of northern Africa, is around 7 metres long, but will attack an animal bigger than itself. Crocodiles lie in the water with just their eyes above the surface. When they get to within 6 metres of their prey, they attack. A few flicks of their powerful tails carry them that distance at amazing speed.

Despite powerful teeth – which are used solely to seize prey – the crocodile cannot chew its food. It either has to swallow it whole, or tear it to pieces by gripping one part of the carcass with its teeth, then rotating on its axis.

The Komodo dragon of Indonesia is the largest species of lizard. It grows up to 3 metres long and lives mainly on small pigs. They can run up to 16 km/h to catch them.

The peregrine falcon can fly at over 360 km/h. The golden eagle dives at more than 240 km/h and a whole range of birds, such as species of swift and goose, fly at more than 100km/h, while man's top speed is a measly 50 km/h.

The fastest animal on Earth is the cheetah, a species of big cat with long and slender legs which has a top speed of around 100 km/h. The cheetah can reach a speed of 72 km/h in two seconds from a standing start. It has this incredible acceleration because, in contrast to many cats, the cheetah has a flexible backbone which allows its hind legs to overtake its forelegs in every bound.

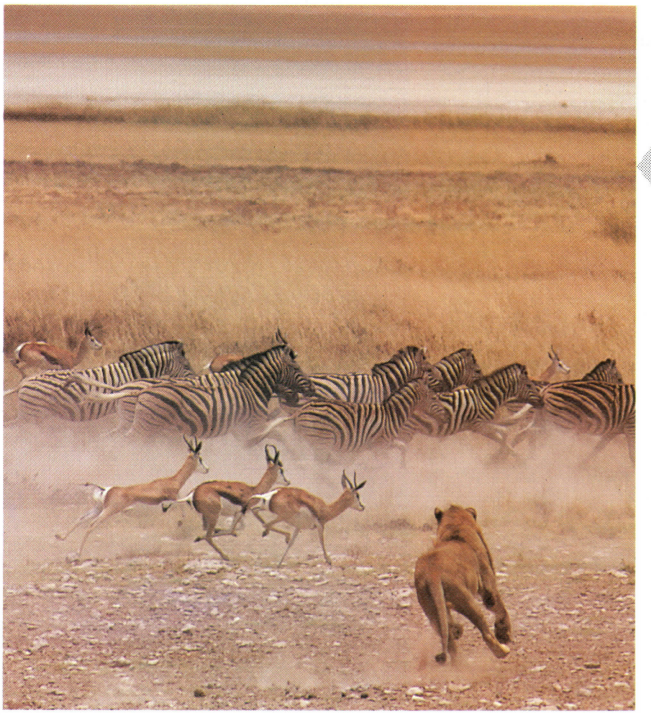
***The elephant** may not be the strongest, or the biggest, or the toughest animal in the world. But when angry it can charge at speeds of up to 40 km/h over distances of 45 metres.*

Not too far behind in the speed stakes are certain types of gazelle and antelope. Racing greyhounds reach speeds of 70 km/h.

Sea speed

In the sea, once the killer whale gets some momentum behind its giant bulk, it can swim at over 50 km/h. The common dolphin and the salmon are around 10 km/h and 20 km/h slower.

The sperm whale can dive to over



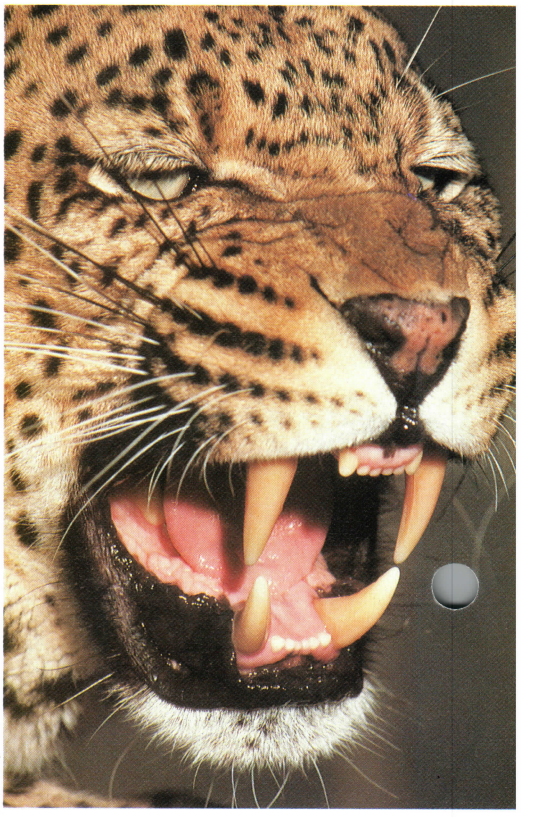
Jen & Des Bartlett/Bruce Coleman Ltd

Young male lions *can cause havoc among herds of springbok and zebra – once they have learned the right tactics. Speed and strength are not enough. Brain power is needed to catch prey that can run faster.*

cells which, upon triggering, inject paralysing poisons into fish or smaller prey. Some marine snails have a poisonous tooth which they use to stab their victims, while insects like bees and wasps have their sting in the tip of the abdomen.

Poisonous fish may have defensive spines on their bodies. Sting-rays have venom glands on their dagger-like tail spine. The tail is raised above the back and stabs forwards and upwards at predators trying to attack them.

Then there are those fishes that



Anthony Bannister/Oxford Scientific Films

Leopards *and other big cats have large teeth and powerful jaws. To kill their prey, they must grip it firmly and pull it to the ground. To do that they must be immensely strong.*

1,000 metres – the longest recorded dive lasted 1 hour 52 minutes. When the whale came up it was harpooned and killed. It had two sharks in its stomach of a type that are only found on the sea floor – which was more than 3,000 metres at that point.

To survive in a very competitive world, clever eye design can help give animals an edge. Flies have complex compound eyes which are highly developed to distinguish movement and colour. Try swatting a fly and you will see how quick off the mark they are.

Sinclair Stammers/Science Photo Library

The strong jaw *and powerful teeth of the hyena, a night hunter which brings down its prey by biting into its legs.*

Despite their small size, most insects can achieve quite phenomenal speed of flight. For example, the hawk moth can reach speeds of around 25 km/h. Most flies can achieve around a quarter of that speed. And some insects flap their wings at an incredible speed during flight. Some species of midge beat their wings 1,000 times a second.

Birds of prey

Birds which hunt prey have eyes in front of them, like those of man, while birds that are hunted have eyes on either side of the head to cover a large field of vision. This helps them see potential attackers.

Many animals produce a poison, either to catch food or as a defence against predators. Sea anemones, jellyfish and corals have stinging

Columbia Tri-Star

The Kodiak bear *is the largest meat-eating animal to live on land. They are found on the Kodiak islands in the Gulf of Alaska.*

can give potential predators an electric shock. The best known is the electric eel, which can jolt its victim with several hundred volts. It also uses this shocking ability to stun smaller fishes as prey.

One of the most remarkable offensive weapons in the marine world is possessed by the archer fish, which swims close to the surface of rivers in its native India and Australia. When it spots potential insect prey on low-hanging tree branches, the fish rises to the surface and spits a jet of water from its mouth which knocks the insect into the river where it is rapidly devoured. The jet effect is achieved with a groove along the fish's mouth. When the tongue is pressed on it the result is a narrow tube. By closing the gills, the fish can eject water under pressure through the tube.

The deep-sea angler fish employs a more subtle method to catch its prey. A fishing rod-like fin grows from its back which can bend round in front of the fish's mouth. A fleshy worm-like growth dangles from the end of the fin, which acts as a bait for smaller fish. When the bait is taken, the angler fish strikes before the prey realizes it has been tricked.

Some marine animals, such as the octopus and cuttlefish, have ink sacs. When threatened, these animals discharge the contents of their sac into the water. This produces a black cloud which enables the animal to escape.

Pincers are a powerful instrument. They are found particularly in crabs and lobsters. Often they are uneven. One pincer may be used for cutting, while the other is more heavily built and is used to crush prey, such as molluscs, which have a tough protective shell. But, if the lobster or crab is attacked, it uses both pincers to defend itself.

Scorpions use a powerful venom for protection against predators, and this can have very unpleasant effects on humans unfortunate enough to come into contact with one. The poison is also used on the insects they hunt for food. But it is just as dangerous to other scorpions, so they have an elaborate courtship dance in order to avoid stinging each other during mating.

Spiders use poisons to subdue their prey and some species, such as the black widow spider, produce such powerful poisons that they can prove lethal to man. Most spiders have a poisonous bite but only a few can harm large animals. Spiders also use silk to catch prey, either in the form of a web, a trip-wire or even a lasso.

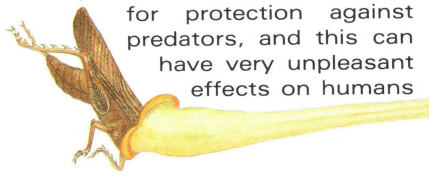
Scorpions and spiders of the desert tend to have very potent venoms. As there is little food, they must be able to quickly kill any prey that they encounter.

Adders, rattlesnakes and cobras inject poison into victims via hollow fangs. The king cobra of south-east Asia is the world's largest species of venomous snake and feeds mainly upon other snakes.

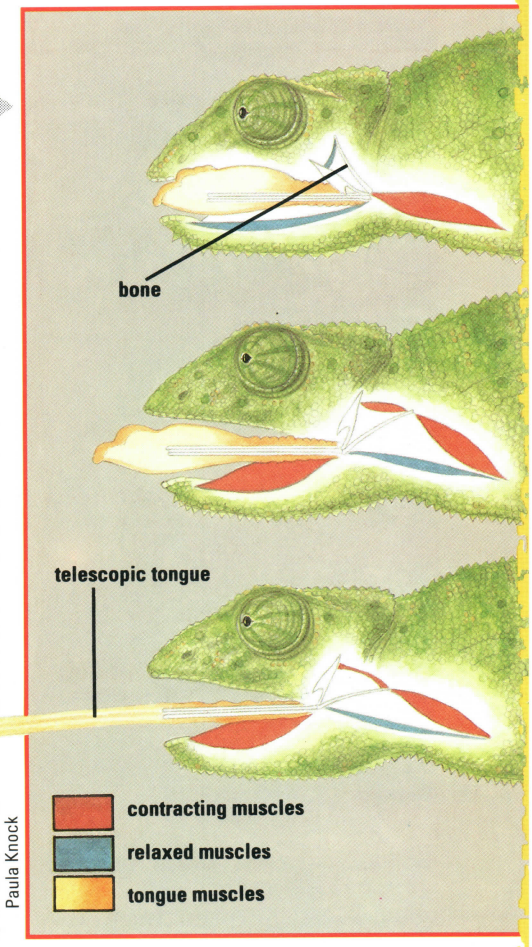
Most snakes have extremely

David Cayless/Oxford Scientific Films

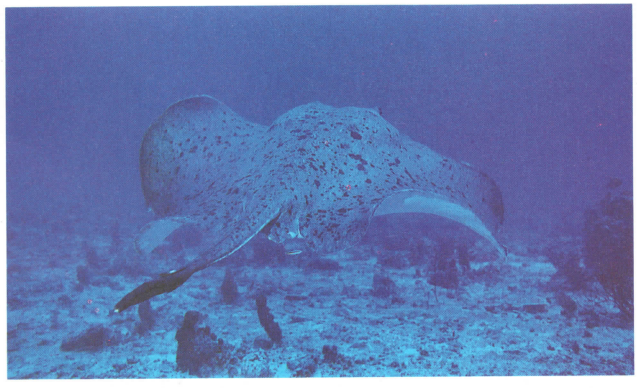
Black rhinoceroses *face each other with the threat of their huge horns – cones of tightly compacted hair. They fight over territory and females.*



The lightning tongue *of the chameleon can easily catch even a fast moving insect like a locust. Its tongue has a hollow tip – for holding the victim – and is operated by a set of specialized muscles.*



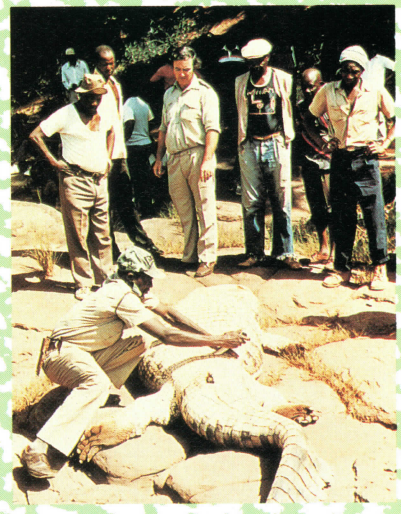
Paula Knock



Herwarth Voigtman/Planet Earth Pictures

The stingray's *tail is covered with sharp spines and coated with venomous slime – which can be fatal to humans. However, it is a defensive, not an offensive weapon and is rarely used. Usually, when disturbed, the ray will swim away.*

EATEN ALIVE



Gamma/Frank Spooner Pictures

The crocodile is one of the most dangerous animals in the world. This one, killed by rangers in South Africa's Kruger National Park, is about to have its stomach split open: inside is a partially digested man. Besides attacking prey that is in the water, crocodiles use their hugely powerful tails to sweep animals – including people – off river banks. Once in the river, they drown their prey, then tear it to pieces with their formidable array of teeth, or swallow it whole. This crocodile's stomach had been carrying its human victim for 3 days, and it also had a wart-hog inside.

Frieder Sauer/Bruce Coleman Ltd

The ant-lion larva *can crush a real ant in its powerful jaws. The ant-lion larva is not really an ant – it is the larva of a separate group of insects called ant-lions.*

mobile jaw-bones which, allied to a stretchable throat skin, enable them to swallow prey much wider than the size of their own head.

The keen-eyed kingfisher swoops with devastating accuracy into rivers where it rarely misses the fish that are its target. Once the fish is grabbed in the kingfisher's strong beak, the wings are used to launch it out of the water. The kingfisher then returns to a nearby branch where the fish is swallowed whole, always head first.

All members of the cat family, which includes lions and tigers, have claws that can be used offensively and defensively. The tiger has one of the most developed sets of claws that are extremely sharp and strong and are used to both grip their prey and defend the tiger against any would-be attacker.

Lions are the largest of the big cats, standing a metre high. They have powerful jaws and sharp teeth and claws, all of which are useful in tearing the flesh of zebra and antelope, their most common form of prey.

Several species of toads and salamander, including arrow-poison frogs, secrete a defensive poisonous substance on their skin. This has a drastic effect on the mouth linings of predators such as dogs which immediately drop the animal and salivate in large quantities to get rid of the terrible taste. Indians in Columbia have used the secretion of the Variable Tree Frog for poisoning the tips of their hunting arrows.

Stink glands

The North American skunk has a highly effective defence mechanism in the form of a powerful smell. The skunk has a pair of stink glands by the tail that shoot a fine spray of golden yellow liquid over several metres. This has a smell strong enough to put off all but the most determined predator.

However, the world's smelliest animal is the African zorilla. The nauseating fluid from its anal glands can be smelt 1.6 km away and a zorilla can keep a pack of lions at bay for several hours.

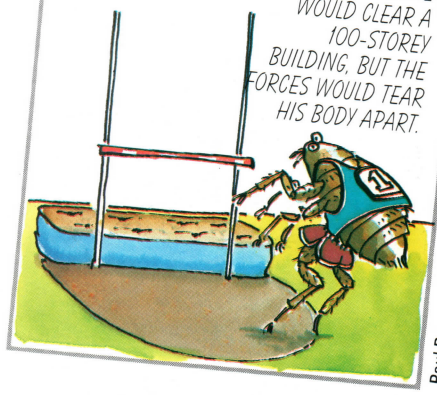
Some animals have developed their teeth into powerful weapons. The wild boar's canine teeth have evolved into tusks with immense gripping power. The razor teeth of a shark have long been known to tear apart human flesh. Their teeth are so sharp that they sometimes tear fishing nets to get at the catch.

Jaw power is not just associated with large animals. The young desert-living ant-lion has very powerful pincer-like jaws which it uses to burrow a hole into the sands. When its prey – ants or spiders – disturb the sand on the hole's edges, the ant-lion reacts by flicking a grain of sand from the top of its head towards its target, knocking the prey into the pit where it is quickly eaten.

Just amazing!

UP, UP AND AWAY

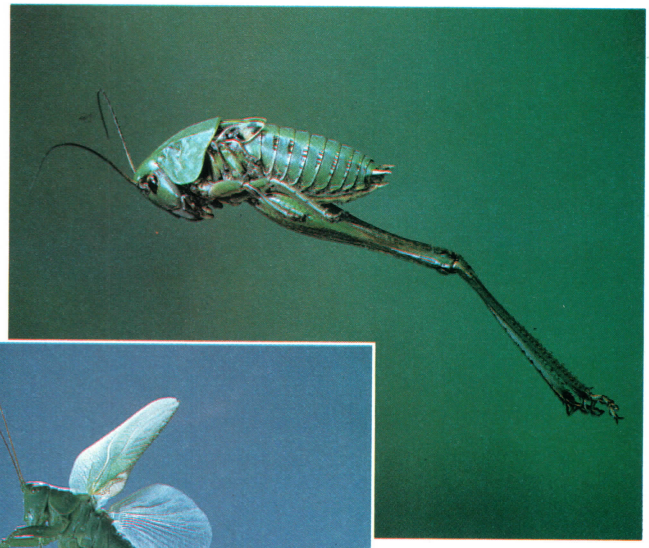
FLEAS CAN JUMP 30 CM HIGH – MORE THAN 200 TIMES THEIR BODY LENGTH. A MAN DOING THE SAME WOULD CLEAR A 100-STOREY BUILDING, BUT THE FORCES WOULD TEAR HIS BODY APART.



Paul Raymonde

David Scharf/Science Photo Library

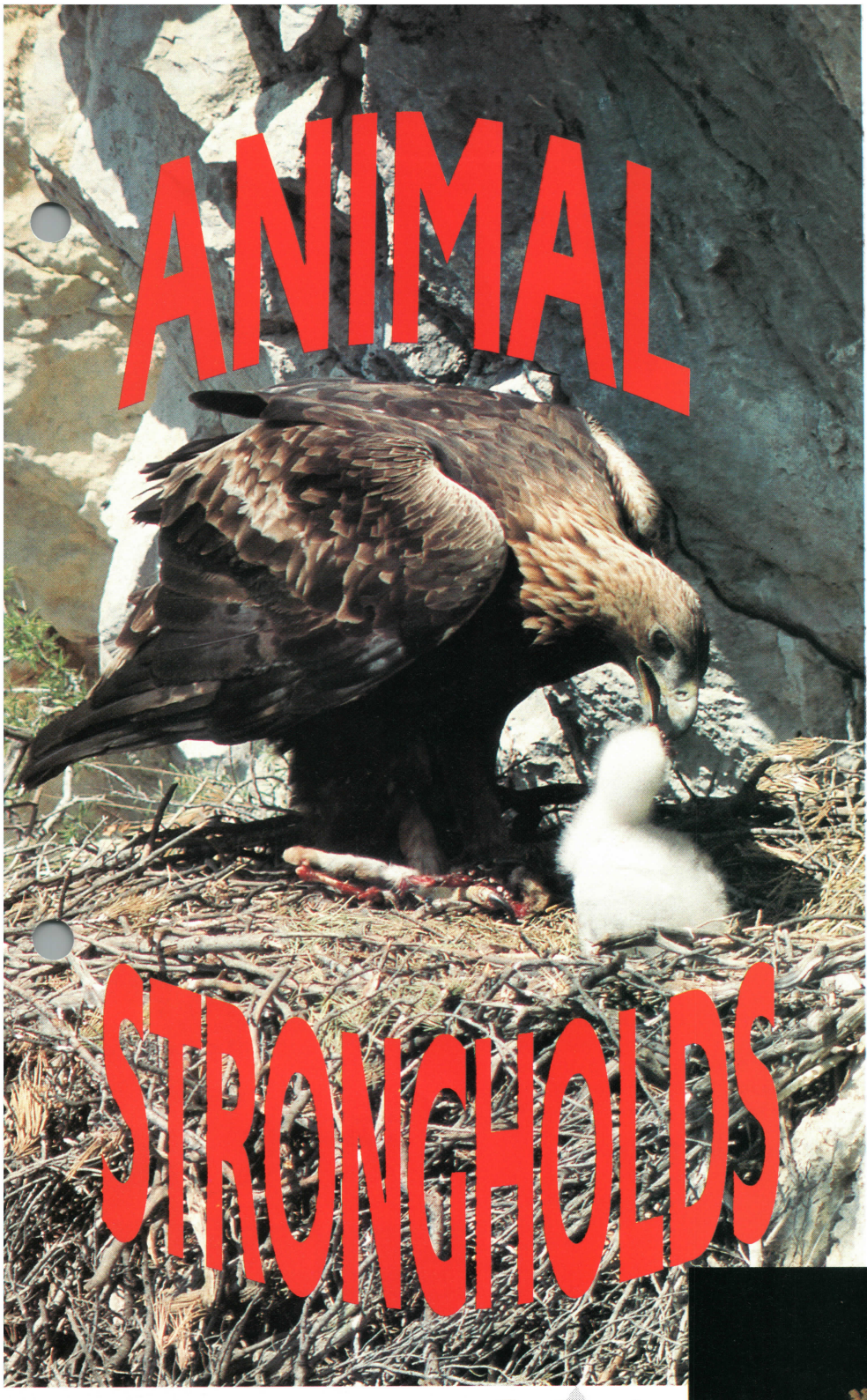
The flea's *hindlegs are specifically designed so that it can jump quickly from host to host, in search of fresh blood to drink.*



ZEFA

The grasshopper's *powerful back legs launch it into the air. Its large wings and wing cases are used to give it extra distance in flight.*

ANIMAL STRONGHOLDS



JLG Grande/Bruce Coleman Ltd

- HUGE COLONIES
- SAFETY FIRST
- COMMUNES

HUMANS ARE NOT ALONE IN feeling a need to build secure homes. Animals choose homes and nests with safety uppermost in their minds.

They need to bring up young and to sleep without fear of attack from predators, and some animals prefer the extra protection of living in a community.

Most ants, termites, bees and wasps are social insects that live in colonies in large numbers. There are estimated to be more than one thousand million million ants on Earth. They produce wings when they reproduce and swarm out of the colony for a short period called a nuptial flight. After mating, the female makes a small chamber in which she lays her eggs. The first larvae develop into wingless worker ants, whose job is to forage for themselves and for the queen.

Ant slaves

In some species, soldier ants are produced to build and defend the colony. In others, worker slaves of another species are captured to do the work.

In some dry areas around the Mediterranean, harvest ants keep seeds in underground storehouses so that they will have a food supply in times of shortage. Most ant colonies are just below the surface, but leaf-cutting ants burrow as deep as 6 metres down, cultivating underground fungus 'gardens' using chewed-up leaves as soil.

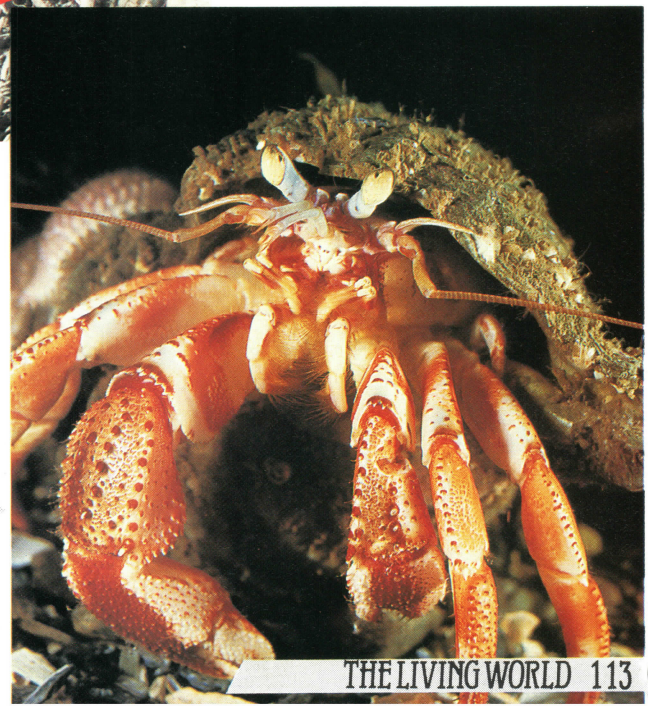
Honey bees

Bees and wasps are other insects that usually live communally. One of the most remarkable social systems belongs to the honey bee, which has been domesticated for centuries. A colony contains a large queen, smaller drones and worker bees. Each has specific work to do and is dependent on the others for survival. The queen and the workers grow from identically fertilized eggs, but the egg and larva of the queen develops in a larger cell. She is also fed on a special diet of 'royal jelly' produced by the worker bees.

The drones are male bees that are formed from unfertilized eggs. They are larger than workers but are shorter and stockier than the queen. They have no sting and their function is solely to mate with virgin

The golden eagle *builds its nest high up in the mountains or in trees to keep the chicks safe from natural predators – and from humans, too.*

The hermit crab *inhabits any shell it can find and is soon covered by sea anemones. They feed on the crab's leftovers and protect the crab.*



ZEFA

MERCILESS SQUATTER

Roger Wilmshurst/Bruce Coleman Ltd

The cuckoo is a uniquely parasitic bird. The female lays her eggs in the nests of much smaller birds, such as the reed warbler (above), replacing one of the host's eggs with one of her own. Birds will often fight off adult cuckoos to prevent them laying eggs, but once laid, they are always hatched and fed. The young cuckoo usually hatches out before the host's eggs and it soon goes about pushing the others out of the nest. The blind, naked chick holds the egg on its back between its wings and instinctively pushes itself backwards up the nest wall until it tips the egg over the edge. The young cuckoo soon fills the nest itself, often dwarfing the host parents who try to satisfy its voracious appetite. After three to five weeks, it leaves the nest.

Robert Wanscheidt/Bruce Coleman Ltd

***Hornets** make their nests out of papier-mâché. They chew up rotten wood to make a sort of cardboard, arranged into hexagonal cells, which contain the larvae (below). The nest is wrapped in more 'paper'.*

Alastair MacEwen/Oxford Scientific Films

queens, in mid-air. Drones are normally present from late April until August, after which any that have survived the summer are forced out of the hive by the workers.

The workers run and organize the colony. They secrete wax to build the comb, gather stores of pollen and nectar, nurse the young and ventilate and guard the colony. They are armed with a barbed sting that they usually only use to defend the colony. When used on humans, the sting cannot be withdrawn because of the barb. It is, therefore, torn from the bee, resulting in its death.

Short, hard life

Worker bees wear themselves out quickly – they only live for about six weeks. Their first job is to clean the cells and act as nurses to the larvae, feeding them and keeping them warm. After about two weeks, their duties change to collecting nectar and pollen; older bees can be recognized by their ragged wings that get worn out because of the heavy loads they carry.

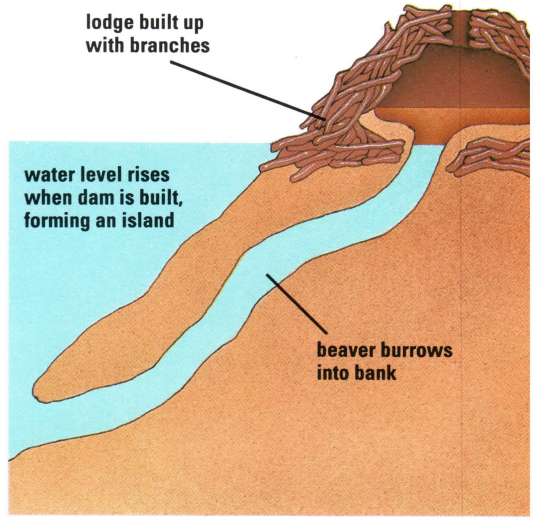
It is not only insects that choose a social life – many mammals prefer communal living, too. The naked mole rat, which actually has a few hairs, is blind and has no exterior ears. Like many small mammals, it excavates a mass of tunnels to form a colony and this contains a reproducing queen, mating males, and nurses.

Working together

The racoon-like meerkat remains a prime example of successful communal living. It lives in the inhospitable Kalahari desert and each member of the colony takes on specific duties to protect each other. These include sentry duty, childminding, hunting, teaching and so on. The colony can comprise up to 20 members, who sleep in a network of burrows.

Within days of the young being born, the mother returns to hunting and they are looked after by a rota of baby sitters. Adults bring back food for them at this stage, but the young soon have to fend for themselves and bring back food for the next litter.

***The beaver** forms its lodge by burrowing into the bank. It piles branches up on the lodge, then dams the stream to raise the water and form an island.*



Mark Franklin

Beavers live in family groups, constructing a complicated island home called a lodge. They first dig a burrow in the bank of a stream, piling branches over the entrance to form a lodge. Then a dam is constructed across the stream to raise the water level and form an island, which gives the family total security from enemies.

Just amazing!

CROWDED COLONY

THE LARGEST ANIMAL 'TOWN' EVER WAS A COLONY OF BLACK-TAILED PRAIRIE DOGS DISCOVERED IN 1901, IN TEXAS. TWICE THE SIZE OF BELGIUM, IT HAD A POPULATION OF 400 MILLION!

Paul Raymonde

Jean Michel Labat/Ardea London

Uncovered meat *attracts flies. These lay white clusters of eggs, which hatch into hungry maggots.*

CREEPY-CRAWLIES

- BED BUGS
- MICROFUNGI
- COCKROACHES

MICROSCOPIC LIFEFORMS too small to be seen are all around us, even in the cleanest home. Most of them do us little or no harm and many are important – even vital – to everyday life.

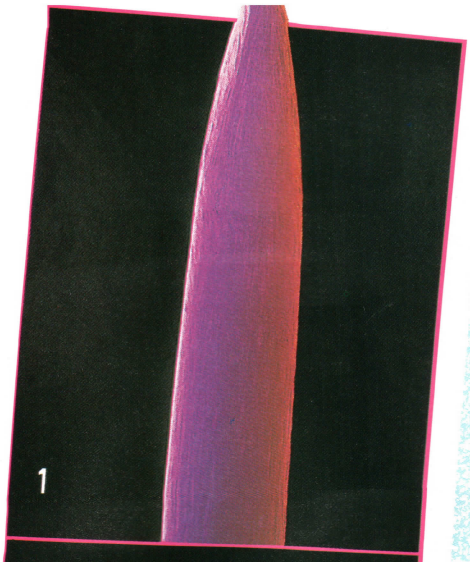
The smallest microscopic lifeforms are the viruses, bacteria and fungi. Viruses multiply only in living cells, so their effects are usually seen as a visible disease – in household plants that develop coloured spots or rings on the leaves for instance. In plants that are badly affected, there may be no other course but to destroy them, because such diseases cannot be treated effectively.

Certain viruses, however, are useful because they attack the cells of bacteria and fungi that cause disease. Those that attack the cells of microbes are called bacteriophages (or phages for short). Some phages have a simple rod shape; others are like miniature spaceships.

Bacteria are living cells. They are bigger than viruses, but are so small that a million or more of them may live on the point of a pin. They become visible to the naked eye only when they have formed a colony of many millions, appearing usually as a jelly-like speck.

David Scharf/Science Photo Library

The strands *of a used kitchen scourer, magnified 200 times through an electron microscope, are clearly covered with clumps of rod-shaped bacteria.*



Dr Tony Brain & David Parker/SPL

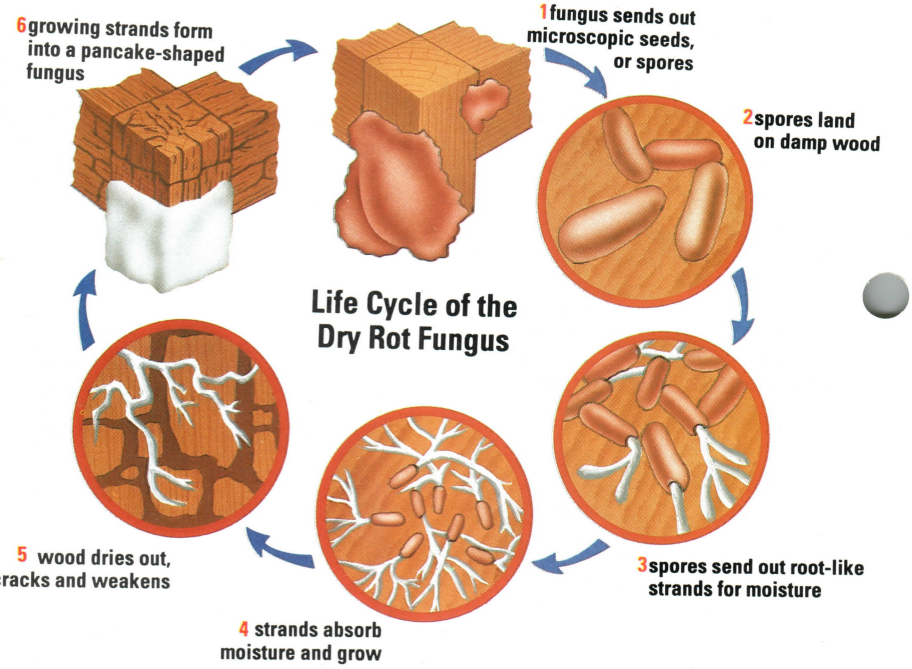
Bacteria are everywhere *but normally unseen. As the point of a household pin is magnified from x7 (1), to x35 (2), x175 (3) and x875 (4), bacilli are revealed.*

WINGLESS WRIGGLER

A flat silvery-grey creature moving with a wriggling motion in the empty bathtub is likely to be a silverfish. It is usually classed with the insects – although it has no wings. The silver-fish is so primitive that it, and its relative the firebrat can be regarded as a 'living fossil'. These harmless little wrigglers eat the starchy paste in books and clothes.

John Howard/Science Photo Library

Dry rot *is caused by a fungus. The air-borne spores (below) settle on damp wood, growing into a pancake-shaped plant, which then emits fresh spores.*



Mark Franklin

In the home, huge colonies of bacteria can sometimes be seen on stale fruit and vegetables. Once established, they dissolve the pectin that holds the cells together and quickly reduce the fruit to a slimy mess.

Rotten feast

Meat is also attractive food to bacteria. Often a bluish colour is the first sign that they are feeding and multiplying, and the food is spoilt long before the foul smell of decay can be detected.

Many foods contain bacteria within them – not just on the surface. If they are kept refrigerated at low temperatures, the growth of these bacteria is greatly reduced. If the food is left out of the refrigerator or freezer, however, the bacteria feed, multiply rapidly in the warmth and spoil the food.

Even handling a piece of meat or other food will add more bacteria to it, because we all have bacteria inside our bodies and on our skins. Usually, however, these are not the bacteria that cause meat to go rotten. In fact, the bacteria on our skin are among the many 'good bugs', because they feed on harmful ones that would otherwise colonize our bodies.

Humans produce large numbers of bacteria. Each gramme of faeces contains 1,000 million or more bacterial cells, which are usually harmless once they have been flushed away into the sewers. Lavatory cleaners that 'kill all known germs' are little more effective than the copper coins they cost, because copper is a powerful bactericide. Pennies in the loo, however, would stain it and leave an

Joyce Photographics/Science Photo Library

Dr Jeremy Burgess/Science Photo Library

unpleasant odour.

Microfungi are among the most numerous of all the microbes in the home – and some are harmful. They are related to the larger fungi, such as mushrooms and toadstools but, as their name implies, they are too small to be seen except through a microscope.

Bad bugs

Microfungi's spores – tiny cells by which they reproduce – float about in the air in vast numbers. We breathe in many of these spores, but the bacteria in our bodies engulf and destroy them before they can cause us harm.

The presence of microfungi can be seen if food, such as bread, is left out in the open to go stale. Within a few days, spores begin to grow on it to form a green or black mould. These spores are mostly of the *penicillium* and *aspergillus* types of microfungus, the two commonest of all air-borne moulds.

Rotting fruit *is a bluish-green (left) because of the penicillium mould (from which the antibiotic penicillin is made), growing on it. The mould is harmful if eaten. The microscopic spores can be quite clearly seen at x750 magnification.*

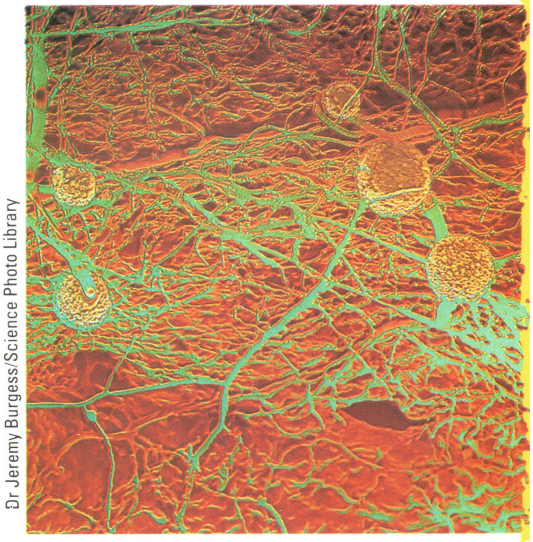
Martin Bond/Science Photo Library

Stale food *is a rich source of nourishment for fungi, as well as maggots, both of which serve a useful purpose – they help to break down rotting matter as Nature's very own waste disposal service.*

Some species of penicillium mould are 'good bugs' because they give penicillin – the important antibiotic drug. Some aspergillus moulds produce chemicals that can cause cancer, but only rarely are humans at risk from them.

The dry-rot fungus, which destroys timber, is a serious household microbe. The fungus needs damp wood at first, but later it gets moisture from the air. It sends out microscopic fungal threads, which can penetrate masonry and bricks to reach, and rot, dry timber – hence the name dry rot. There are chemicals that kill dry rot for, left unchecked, it can weaken the structure and bring it down.

Less serious, but highly unsightly, are various kinds of fungi that cause patches of jelly-like growths on damp walls. These, unlike dry rot, can be killed simply by drying the walls and so cutting off the



Dr Jeremy Burgess/Science Photo Library

Mould growing *on a slice of bread – as seen, magnified 30 times, in a false-colour photograph.*

Just amazing!

GIANT SPINNER

A BRITISH HOUSEWIFE COAXED FROM HER BATH A COMMON HOUSE SPIDER WITH A LEG SPAN OF 140 MM – THE SIZE OF A HAND.

Paul Raymonde

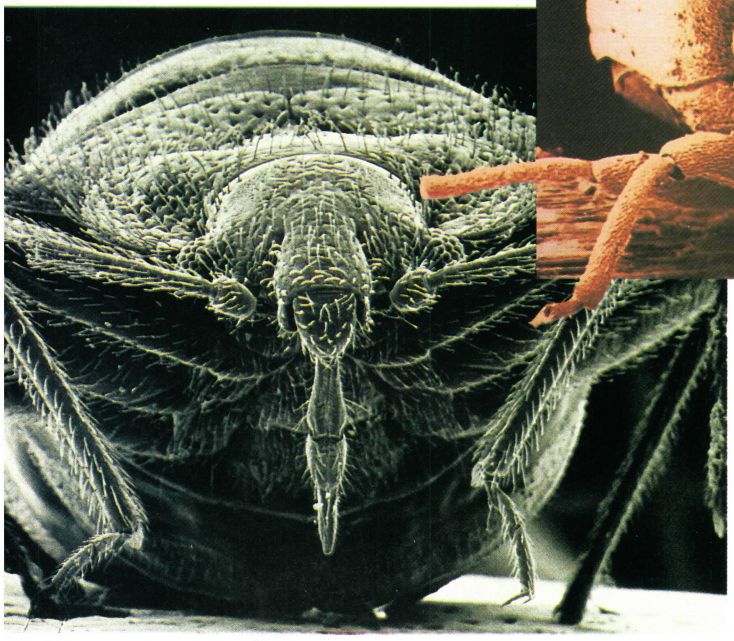
Dr Jeremy Burgess/Science Photo Library

supply of moisture the fungi need.

Chemical sprays used to kill insect and microbial pests might leave residues on fruit and vegetables that could be toxic to humans as well as to the bugs they are intended to destroy. A less-harmful method of control is to breed food plants to have greater resistance to pests and diseases.

Compared with microbes, insects

A cheese mite *– quite common in kitchens – crawls through strands of penicillium fungus as it feeds on mouldy cheese.*



Swollen *after its meal of human blood, a bed bug (magnified x15) will not need to eat again for several days.*

infest our homes in much smaller numbers, at least in cooler countries. In the tropics, hordes of termites – ant-like creatures – can bring a house down by destroying its timber. Living in the gut of termites are single-celled organisms called flagellates, which produce enzymes that digest the wood.

Cockroaches may infest homes in which food is dropped and left in concealed spaces. Once they are established in numbers, fumigation with poison gas is the most effective means of killing them. Creatures such as beetles, silverfish, spiders and centipedes, however, rarely reach plague numbers and are not dangerous. Fleas can infest both humans and animals and are equally at home on either dirty or clean hosts. They are killed by special sprays.

Bed bugs are still a problem in some badly kept hotels. These are fat insects which hide during the day – in bed clothing, mattresses, bed frames or behind wallpaper – then creep out at night to feed on blood via their piercing mouthparts. They may take several days to digest a meal and adult bugs have been known to survive more than a year without food.

House pests

Clothes moth caterpillars used to be a menace in clothes cupboards when garments were mostly made of wool and cotton. Today, these pests are still a problem, even though most cloth contains large amounts of inedible, synthetic fibres.

Furniture beetle, or woodworm, burrows through wood, reducing it to a network of holes and trails of powder. All structural timber is treated with an insecticide to control woodworm. Some items of furniture, however, are untreated, and the pest is usually introduced into the home in old or antique furniture.

Woodworm only attack old wood – soft wood that is at least 20 years old and hard wood that is at least 60 years old.

Dr Tony Brain & David Parker/SPL

A woodworm *beetle crawls out of a hole in a piece of furniture. Although it is a domestic pest, in the wild it aids the decomposition of dead trees.*

Dr Tony Brain/Science Photo Library

Mice *may be the most visible of household guests but they are also the most harmless – living of scraps of food dropped on the floor. This family has made its home in a cavity wall.*

Liz & Tony Bomford/Ardea London